Operational safety including operational feedback
Background

In 1991, the General Conference (GC) in its resolution RES/552 requested the Director General to prepare 'a comprehensive proposal for education and training in both radiation protection and in nuclear safety' for consideration by the following GC in 1992. In 1992, the proposal was made by the Secretariat and after considering this proposal the General Conference requested the Director General to prepare a report on a possible programme of activities on education and training in radiological protection and nuclear safety in its resolution RES1584.

In response to this request and as a first step, the Secretariat prepared a Standard Syllabus for the Post-graduate Educational Course in Radiation Protection. Subsequently, planning of specialised training courses and workshops in different areas of Standard Syllabus were also made. A similar approach was taken to develop basic professional training in nuclear safety. In January 1997, Programme Performance Assessment System (PPAS) recommended the preparation of a standard syllabus for nuclear safety based on Agency Safely Standard Series Documents and any other internationally accepted practices. A draft Standard Syllabus for Basic Professional Training Course in Nuclear Safety (BPTC) was prepared by a group of consultants in November 1997 and the syllabus was finalised in July 1998 in the second consultants meeting.

The Basic Professional Training Course on Nuclear Safety was offered for the first time at the end of 1999, in English, in Saclay, France, in cooperation with Institut National des Sciences et Techniques Nucleaires/Commissariat a l`Energie Atomique (INSTN/CEA). In 2000, the course was offered in Spanish, in Brazil to Latin American countries and, in English, as a national training course in Romania, with six and four weeks duration, respectively. In 2001, the course was offered at Argonne National Laboratory in the USA for participants from Asian countries. In 2001 and 2002, the course was offered in Saclay, France for participants from Europe. Since then the BPTC has been used all over the world and part of it has been translated into various languages. In particular, it is held on a regular basis in Korea for the Asian region and in Argentina for the Latin American region.

In 2015 the Basic Professional Training Course was updated to the current IAEA nuclear safety standards. The update includes a BPTC text book, BPTC e-book and 2 “train the trainers” packages, one package for a three month course and one package is for a one month course. The” train the trainers” packages include transparencies, questions and case studies to complement the BPTC.

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Editorial Note

The update and the review of the BPTC was completed with the collaboration of the ICJT Nuclear Training Centre, Jožef Stefan Institute, Slovenia and IAEA technical experts.
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1 INTRODUCTION

Learning objectives

After completing this chapter, the trainee will be able to:

1. Define how different aspects of nuclear power plant operation impact on nuclear safety.

In order to ensure nuclear safety, it is very important how nuclear power plants, research reactors and all other nuclear facilities are operated. Operational safety is a very broad topic that covers every aspect of the operation of nuclear facilities. For safer operation the industry itself ensures that various events (failure, abnormal operation, accidents) during operation are recorded and communicated to all those dealing with the same or similar activities. Such a mode of communication or dissemination of information is called operating experience. Operating experience feedback should be subject to certain rules so that everyone can understand the information correctly, and then use it in their work, thus improving nuclear safety.

The IAEA has issued various documents relating to operational safety and operational experience feedback. The objective of this module is to gather together and briefly summarize in one place the various documents issued under the auspices of the IAEA dealing with operational safety and operational experience feedback.

The first part of this module is a summary of the IAEA documents that deal with mentioned topic. Because of the breadth of this topic we limited ourselves only to the operation of nuclear power plants. The publication which covers all aspects of the operation of nuclear power plant is Specific Safety Requirements No. SSR-2/2, which is a revision of the Safety Standards Series No. NS-R-2.

Regardless of the kind of working organization, leadership and an organized structure to manage and run the working process is required. This topic is found in various IAEA documents under the title “The operating organization”. The tasks and duties performed by the operating organization are clearly defined in these documents, but they all share the same goal which is nuclear safety. In general the tasks and duties of the operating organization are as follows:

- General requirements; To define who is primarily responsible for operational safety and nuclear safety, how the power plant management leadership is determined and what is the interdependence between its members.
- The interface with the regulatory body; The regulatory body is important ensuring safe operation, because it is responsible for the independent supervision of the nuclear power plant. The operating organisation is obliged to report each and every abnormal event to the regulatory body.
- Operational experience feedback; Operational experience is very
important for operational safety, and is a good source of information from which it is possible to predict in advance possible events and take action to prevent them before they occur.

- Fire safety; Fire may critically affect safety during operation and therefore plans, training, etc., are needed to ensure the right actions are taken in the event of a fire.
- Emergency preparedness is difficult to connect directly with operational safety, but continuous training must take place in this area also during the plant operation.
- Quality Assurance is needed to ensure that the nuclear power plant is operating efficiently and safety, and that there is a high degree of confidence that all project activities will be performed correctly and that failures, mistakes, and deficiencies in the design, construction and operation of the nuclear power plant will be avoided, or at least detected and rectified in a timely manner.
- Physical Protection; As the name implies, it is necessary to protect the nuclear power plant from any unauthorized access that could jeopardize operational safety.

The IAEA has issued many documents on the topic of Training and Qualification. For safe operation of a nuclear power plant it is very important to have a well trained staff. It is also very important that staff training includes operational experience feedback from events in the power plant, as well as from other power plants. In this way events may be foreseen and prevented in a timely manner, thus helping to increase safety during operation. In addition, a well trained staff make fewer human errors, which also contributes to greater safety during operation.

Commissioning is especially important for safe operation, because only in this way a power plant built according to project plans and thoroughly tested can operate within the Operating Limits and Conditions, thus ensuring safe operation and nuclear safety.

Plant operations may be divided into three main parts, each playing a role in nuclear safety:

- Operational limits and conditions: Taking these into consideration means that the nuclear power plant will operate safely in accordance with the design assumptions and purpose, which is a prerequisite for nuclear safety.
- Operating instructions and procedures: For safe operation, it is mandatory to have clear instructions and procedures that are written on the basis of the power plant project, the various tests, safety assessments and operational experience. In this way the number of human errors can be reduced and inadequate responses to the operational status of the plant avoided, and thus nuclear safety be improved.
- Core management and fuel handling: Only the correct design of
the core and safe handling of fuel is a guarantee of nuclear safety. The core project must ensure safe and controlled changes of power. Fuel handling must be carried out in accordance with authorized procedures to reduce the possible adverse effect of radiation on human beings and environment.

Maintenance, testing, surveillance and inspection are equally important for nuclear safety, together with operation in accordance with operating instructions and procedures. Only well maintained equipment which is subject to supervision, testing, qualification, etc., can be used to operate and carry out project requirements. For all work on equipment there should be procedures that accurately describe the arrangements for its maintenance, testing, surveillance and inspection, and thus ensure the proper functioning of equipment. In this type of work good operational experiences which could shorten the working time and improve the quality of the work done are welcome and important.

In a given situation it is necessary to improve nuclear safety, and to increase the efficiency of production. To do that some changes on systems, equipment, etc. are needed. So-called plant modifications are often performed in the nuclear industry, but any such changes must be properly planned, screened by independent institutions and by the regulatory body in order to avoid any possible adverse effects on safe operation or nuclear safety. In any such modification which changes the power plant project (design), operating experiences from other nuclear power plants must be considered.

Because of the specificity of nuclear power plants, it is necessary to pay attention to radiation protection and radioactive waste management at all times. During plant operation and outages, workers may be exposed to radiation. This requires that all work must be properly planned and implemented in order to prevent adverse effects on the health of employees and the environment. For most activities the ALARA principle is used.

Control of records and reports is important for operational safety because it is vital that staff are always aware of the last valid revision of procedures, instructions, etc., which takes into account the actual state of the nuclear power plant, and that this also includes the latest known operating experience from the entire industry. From the point of view of nuclear safety the use of the latest documents is important, because it reduces the number of human errors due to incorrect use of equipment and systems.

The purpose of the periodic safety review (PSRs) is to evaluate operational safety according to the latest safety standards and operating experience. The report then forms the basis for corrective action and upgrading, which in turn leads to greater nuclear safety.
For decommissioning of a nuclear power plant its operation is important mainly due to the accumulation of experience in radiation protection and radioactive waste management, helping to ensure that the radiological exposure to humans and the environment after shutdown of the plant, is as low as possible.

The second part of this module provides a summary of the expected performance in several important areas of operational safety taken from the Operational Safety Review Team (OSART) Guidelines. This information gives the reader useful information on those attributes of plant operations judged to be most important for review by international experts in the course of an OSART mission.
2 SAFETY OF NUCLEAR POWER PLANTS: OPERATION

Learning objectives
After completing this chapter, the trainee will be able to:

1. Describe the general requirements to be met by the operating organization for safe operation.
2. Describe the interface between the operating organization and the regulatory body.
3. State the purpose of operational experience feedback.
4. Define fire safety requirements for a nuclear power plant.
5. State the purpose of the emergency preparedness programme for a nuclear power plant.
6. Describe the purpose of the quality assurance programme in a nuclear power plant.
7. Define the physical protection programme for a nuclear power plant.
8. Describe the training and qualification programme for personnel in a nuclear power plant.
9. Explain the purpose of the commissioning programme in a nuclear power plant.
10. Describe the most important programmes for safe plant operation.
11. List the general requirements for maintenance, testing, surveillance and inspection in a nuclear power plant.
12. Define the term "plant modification".
14. Explain the purpose of the control of records and reports.
15. Explain the purpose of the periodic safety review in a nuclear power plant.
16. State the importance of nuclear power plant operation for decommissioning.

2.1 The management and organizational structure of the operating organization

Responsibilities of the operating organization
This chapter covers the main requirements that must be met by the operating organization to ensure safe operation. The operating organization may delegate authority to the plant management for the safe operation of the plant, but it retains prime responsibility for nuclear safety. In such cases the operating organization must provide the necessary resources and support. Plant management must ensure that the plant is operated in a safe manner, and in accordance with all legal and regulatory requirements. For the operating organization it is important that they establish and implement policies that give safety matters the highest priority. The policy on nuclear safety is developed
by the operating organization and implemented by all site personnel. This policy gives plant safety the utmost priority, overriding if necessary the demands of production and project schedules. It requires a commitment to excellence in all activities important to the safety of the plant and encourages a questioning culture. In establishing the structure of the organization, consideration is given to its four main functions, i.e. policy making, operating, supporting and reviewing.

A documented organizational structure is established by the operating organization to ensure that all functions and responsibilities inherent to the operating organization with respect to achieving safe operation of the nuclear power plant are discharged. This structure indicates the staffing arrangements within the categories of direct line operating personnel and supporting personnel. Clear lines of authority are established to deal with matters bearing on nuclear plant safety.

The operating organization is staffed with competent managers and sufficient qualified personnel having the proper awareness of the technical and administrative requirements for safety and the motivation to adopt a conscious safety culture. Safety culture is one of the selection criteria when hiring or promoting managers. Suitably qualified and experienced persons must perform all activities that may affect safety in accordance with established procedures which are submitted to the regulatory body for approval, if so required. When activities are proposed that are not included in the normal procedures, special procedures must be written in accordance with established administrative practice. These special procedures include the contents and the operational details of the proposed activity. Such activities and special procedures are carefully reviewed for safety implications. The approval of these special procedures follows the same process as that for the normal procedures of the plant.

The operating organization ensures regular reviews are carried out of the operation of the nuclear power plant with the aim of ensuring that an appropriate safety consciousness and culture prevails, that the provisions set forth for enhancing safety are observed, that documentation is up to date and that no signs of over-confidence or complacency is appear. The results are made available to plant management and appropriate corrective actions taken.

Management system

The operating organization must establish, implement, assess and continually improve an integrated management system.
The operating organization prepares and puts in place a comprehensive quality assurance programme covering all activities which may affect the safe operation of the plant. Quality assurance is an integral part of every activity that may affect safety. The principles and methods of quality assurance are used systematically in:

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

**Structure and functions of the operating organization**

The structure of the operating organization and the functions, roles and responsibilities of its personnel are established and documented.

Functional responsibilities, lines of authority, and lines of internal and external communication for the safe operation of a plant in all operational states and in accident conditions are clearly specified in writing.

The structure of the operating organization is so defined that all roles that are critical for safe operation are specified and described. Proposed organizational changes to the structure and associated arrangements, which might be of importance to safety, are analysed in advance by the operating organization. Where so required by the State’s regulations, proposals for such organizational changes are submitted to the regulatory body for approval.

**Staffing of the operating organization**

The operating organization must be staffed with competent managers and sufficient qualified personnel for the safe operation of the plant.

The operating organization is responsible for ensuring that the necessary knowledge, skills, attitudes and safety expertise are sustained at the plant, and that long term objectives for human resources policy are developed and are met.

The organization, qualifications and number of operating personnel are adequate for the safe and reliable operation of the plant in all operational states and in accident conditions.

The shift team is staffed to ensure that sufficient authorized operators are present to operate the plant in accordance with the operational limits and conditions. To avoid overburdening control room operators and to allow them to focus on their responsibilities for safety, duties are scheduled to reduce simultaneous activities as far as possible.
A staff health policy is instituted and maintained by the operating organization to ensure the fitness for duty of all personnel.

**Interface with the Regulatory Body**

The independent regulatory body is important for safe operation of nuclear power plants, because of its supervisory role. It is essential to the achievement of their common objective, i.e. safe operation of nuclear power plants, that there is mutual understanding and respect between the regulatory body and the operating organization in order to support a frank and open but formal relationship. To enable the regulatory body to carry out its functions, the operating organization gives it all necessary assistance and access to the plant and documentation. Occasionally the regulatory body can require a special analysis, tests and inspections. The operating organization must comply and make available documents and other information in accordance with the requirements of the regulatory body. The operating organization must develop and implement a procedure for reporting abnormal events to the regulatory body in accordance with established criteria. If the request of the regulatory authority could have an adverse effect on safety, then, in view of the prime responsibility for safety, this opinion of the operating organization must be presented to the regulatory body as a basis for further discussions.

**Physical Protection**

All reasonable precautions must be taken to prevent persons from deliberately carrying out unauthorized actions that could jeopardize safety. The operating organization takes 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. The operating organization has plans and procedures in place to provide for physical protection of the site in the event of civil disturbances.

**IAEA safety standards and additional information**

1. Safety Requirements GS-R-3, The Management System for Facilities and Activities;
   - The contents of this publication cover improvement of the safety performance of the organization through planning, control and supervision, and by fostering and supporting a strong safety culture.
   - It is also applicable to the establishment, implementation, assessment and continual improvement of management systems for: nuclear facilities, activities using sources of ionizing radiation, radioactive waste management, radiation protection, transport of radioactive material, etc.

This publication provides generic guidance for establishing, implementing, assessing and continually improving the management system and is similar to the Safety Requirements GS-R-3.

It describes the management system structure, the responsibility of the management, how to deal with resources (all kinds), process implementation and measurement, assessment and improvement.

- The objective of this publication is to provide recommendations and guidance for establishing, implementing, assessing and continually improving a management system that integrates elements of safety, health, environment, security, quality and economics.
- This Safety Guide is applicable throughout the lifetime of a nuclear installation, including any subsequent period of institutional control, until there is no significant residual radiation hazard.

4 Safety Guide NS-G-2.4, The Operating Organization for Nuclear Power Plants;
- The contents of this publication describe how to set up the operating organization, the important organizational elements necessary for a strong safety culture and how to achieve good performance in terms of safety.
- It identifies the main safety objectives and responsibilities of management with respect to safe operation.
- At the end, this publication discusses the relationship between the operating organization, the regulatory body and the general public.

5 Safety Guide NS-G-2.8, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants;
- In order to achieve and maintain high levels of safety, nuclear power plants are required to be staffed with an adequate number of highly qualified and experienced personnel. Therefore, this publication provides general recommendations on the recruitment and selection of plant personnel and on the training and qualification practices.

- The purpose of this publication is to provide states with recommendations to ensure that plant operations are conducted in a safe, effective, thorough and professional manner, in accordance with the requirements established in Safety Standards Series No. NS-R-2 (SSR-2/2 Safety of Nuclear Power Plants: Commissioning and Operation).
- It identifies the main responsibilities and operating practices of the operations department which controls the operation of the NPP.

- This publication provides general guidance for meeting the requirements for the operating organization of a research reactor and for the recruitment, training and qualification of its personnel.
- It describes the typical organization of research reactor facilities.
- It covers the recruitment process and the qualifications to be required in terms of education, training and experience; the initial training programme and the continuing training programme; the authorization process for individuals whose duties have an immediate bearing on safety; and the process involved in the requalification and reauthorization of such individuals.

8 OSART Guidelines Section 3.1, Management, Organization and Administration.

2.2 Management of operational safety

Safety policy

The operating organization establishes and implements operational policies that give safety the highest priority.

The operational policy established and implemented by the operating organization gives safety the utmost priority, overriding the demands of production and project schedules. The safety policy promotes a strong safety culture, including a questioning attitude and a commitment to excellent performance in all activities important to safety.

The safety policy clearly stipulates the leadership role of the highest level of management in safety matters. Senior management communicate the provisions of the safety policy throughout the organization. Safety performance standards are developed for all operational activities and are applied by all site personnel. All personnel in the organization are made aware of the safety policy and of their responsibilities for ensuring safety.

Key aspects of the safety policy are communicated to external support organizations, including contractors, so that the operating organization’s requirements and expectations for the safety related activities of external support organizations, including contractors, are understood and met.

The safety policy of the operating organization includes commitments to perform periodic safety reviews of the plant throughout its
operating lifetime in compliance with the regulatory requirements.

The safety policy of the operating organization includes a commitment to achieving enhancements in operational safety.

**Operational limits and conditions**

Operational Limits and Conditions (OLC) must be developed to ensure that the plant is operated in accordance with the design assumptions and intent. The operational limits and conditions may be classified as:

- Safety limits;
- Limits on safety system settings;
- Limits and conditions for normal operation and for safe transient operational states;
- Surveillance and testing requirements;
- Action statements for deviations from normal operation.

A nuclear power plant must be operated in accordance with the Operational Limits and Conditions (OLCs) to maintain nuclear safety.

The OLCs also cover actions to be taken and limitations to be observed by the operating personnel. The OLC must form an important part of the basis on which the operating organization is authorized to operate the plant. The OLCs are 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 must be substantiated by a written indication of the reason for its adoption. Reviewing the OLC is an on-going process during the operating life of the nuclear power plant in the light of experience, technological and safety developments and changes in the plant. The OLCs can be modified if required.

The operating organization ensures that a suitable surveillance programme, including evaluation, documentation and storage of results, necessary to ensure compliance with the OLCs is established and correctly implemented.

An appropriate programme must be established to ensure that deviations from OLCs are documented and reported in an appropriate manner and appropriate actions taken, including an update of the safety analysis report if required.

**Qualification and training of personnel**

The operating organization bears prime responsibility for the qualification of nuclear power plant personnel. In connection with that it must define the qualifications and experience to be met by personnel performing duties which may affect safety. Suitably qualified personnel are selected and given the necessary training and instruction to enable them to perform their duties correctly in relation to the
operational states of the plant and in accidents, in accordance with the appropriate operating or emergency procedures. Persons performing certain functions important to safety are required to hold a formal authorization. Such formal authorization in accordance with national requirements is under the jurisdiction of the regulatory body. The plant manager is directly responsible for the qualification of plant staff and supports the training organization with the necessary resources and facilities. Line managers and supervisors are responsible for the competence of their personnel. They are involved in defining the training needs, and ensuring that the training reflects operating experiences. Managers and supervisors must ensure that production requirements do not conflict with the conduct of the training programme.

For each major group of personnel there must be developed and implemented a performance-based programme for initial and continuing training. The content of each programme is based on a systematic approach. Training programmes encourage a positive safety culture. A programme is implemented to ensure that operational experience feedback of events at the plant concerned, as well as of applicable events at other plants, are appropriately considered in the training programme. The programme must ensure that training is conducted on the root cause(s) of events and on the identification and implementation of corrective actions to prevent their recurrence. A programme is implemented to assess and improve the training programmes.

Plant staff must receive instructions in the management of accidents beyond the design basis. Constant training of operating personnel ensures their familiarity with the symptoms of accidents beyond the design basis and the procedures for accident management.

**Performance of safety related activities**

The operating organization ensures that safety related activities are adequately analysed and controlled to ensure that the risks associated with the harmful effects of ionizing radiation are kept as low as reasonably achievable.

All routine and non-routine operational activities are assessed for potential risks associated with the harmful effects of ionizing radiation. The level of assessment and control depends on the safety significance of the task.

All activities important to safety are carried out in accordance with written procedures to ensure that the plant is operated within the established operational limits and conditions.

Written communication is preferred and spoken communication is minimized.
Aspects of the working environment that affect human performance and the effectiveness and fitness of personnel for duty must be identified and controlled.

The responsibilities and authorities for restarting a reactor after an event leading to an unplanned shutdown or major transient, or to an extended period of maintenance, are clearly established in writing. An investigation is carried out to determine the cause of the event and corrective actions are taken to make its recurrence less likely.

**Monitoring and review of safety performance**

The operating organization must establish a system for continuous monitoring and periodic review of the safety of the plant and of the performance of the operating organization.

An adequate audit and review system is established by the operating organization to ensure that its safety policy is being implemented effectively and that lessons are being learned from its own experience and from the experience of others to improve safety performance.

Self-assessment by the operating organization is an integral part of the monitoring and review system and is needed to identify achievements and to address any degradation in safety performance.

Monitoring of safety performance includes:
- the monitoring of personnel performance,
- attitudes to safety,
- response to infringements of safety, and
- violations of operational limits and conditions, operating procedures, regulations and licence conditions.

The persons and organization performing quality assurance functions have sufficient authority and organizational independence to identify problems relating to quality, and to initiate, recommend and verify the implementation of solutions.

The appropriate corrective actions are determined and implemented as a result of the monitoring and review of safety performance. Progress in taking corrective actions is monitored to ensure that such actions are completed within appropriate timescales.

**Control of plant configuration**
Controls on plant configuration ensure that changes to the plant and its safety-related systems are properly:

- identified,
- screened,
- designed,
- evaluated,
- implemented and
- recorded.

Proper controls are implemented to handle changes in plant configuration that result from maintenance work, testing, repair, operational limits and conditions, and plant refurbishment, and from modifications due to ageing of components, obsolescence of technology, operating experience, technical developments and results of safety research.

**Plant modifications**

Plant modifications include modifications of structures, systems, and components, modifications of limits and conditions, modifications of instructions and procedures, and organizational changes. All kind of modifications (permanent or temporary) must be categorized according to their safety significance and approved by the regulatory body. Temporary modifications must be clearly identified at the point of application.

**All modifications must be categorized according to their safety significance and approved.**

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

Installation and testing of plant modifications must be performed in accordance with the plant's work control system and appropriate testing procedures.

Operating personnel must be clearly informed of all kind modifications and of their consequences on the operation of the plant and safety, under all operating conditions. Prior to putting the modified plant into operation, all relevant documents necessary for the operation of the modified plant (in particular the documents for shift operators) must be updated and personnel trained as appropriate.

**Periodic safety review**

A systematic safety reassessment of the plant, which may be fulfilled
by a periodic safety review (PSR), must 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. The PSR determines to what extent the existing safety report remains valid. It takes into account the actual status of the plant, operating experience, predicted end-of-life state, current analytical methods, current safety standards and current knowledge. In order to complement the deterministic assessment, consideration is given to the use of probabilistic safety assessment (PSA) as input to the PSR to provide insight into the relative contributions to safety of different aspects of the plant. Based on the results of the systematic safety reassessment, the operating organization implements any necessary corrective actions and any reasonably practical modifications to comply with current standards.

**Equipment qualification**

The operating organization must ensure that a systematic assessment is carried out to provide reliable confirmation that safety related items are capable of the required performance for all operational states and for accident conditions.

Appropriate concepts and the scope and process of equipment qualification are established, and effective and practicable methods are used to upgrade and preserve equipment qualification. A programme to establish, confirm and maintain the required equipment qualification is launched from the initial phases of design, supply and installation of the equipment.

The scope and details of the equipment qualification process must be documented and submitted to the regulatory body for review and approval.

**Ageing management**

The operating organization must ensure that an effective ageing management programme is implemented to ensure that required safety functions of systems, structures and components are fulfilled over the entire operating lifetime of the plant.

The ageing management programme determines the consequences of ageing and the activities necessary to maintain the operability and reliability of structures, systems and components. The ageing management programme is coordinated with, and is consistent with, other relevant programmes, including the programme for periodic safety review.
Long term effects arising from operational and environmental conditions are evaluated and assessed as part of the ageing management programme.

**Records and reports**
The operating organization makes arrangements for control of records and reports important to safety in accordance with the established quality assurance system. The document management system ensures 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 situation must be considered.

**Programme for long term operation**
The operating organization establishes and implements a comprehensive programme for ensuring the long term safe operation of the plant beyond the time-frame established in the licence conditions, design limits, safety standards and/or regulations.

The comprehensive programme for long term operation deals with:
- Preconditions (including the current licensing basis, safety upgrading and verification, and operational programmes);
- Setting the scope for all structures, systems and components important to safety;
- Categorization of structures, systems and components with regard to degradation and ageing processes;
- Revalidation of safety analyses made on the basis of time limited assumptions;
- Review of ageing management programmes in accordance with national regulations;
- The implementation programme for long term operation.

**IAEA safety standards and additional information**
1. Safety Requirements GS-R-3, The Management System for Facilities and Activities;
   - Briefly described in section 2.1 ‘The management and organizational structure of the operating organization’, under IAEA safety standards;
   - Briefly described in section 2.1 ‘The management and organizational structure of the operating organization’, under IAEA safety standards;
   - The purpose of this publication is to provide guidance on the development, content and implementation of operational limits and conditions (OLCs) and operating procedures (OPs).
   - This covers the concept of OLCs, their content as applicable to power plants with thermal neutron reactors, and the responsibilities of the operating organization regarding their
establishment, modification, compliance and documentation.

   - This publication provides guidance and recommendations on controlling activities relating to modifications at nuclear power plants.
   - It deals with the intended modification of structures, systems and components, operational limits and conditions, procedures and software, and the management systems and tools for the operation of a nuclear power plant.

   - Briefly described in section 2.1 ‘The management and organizational structure of the operating organization’, under IAEA safety standards;

   - Briefly described in section 2.1 ‘The management and organizational structure of the operating organization’, under IAEA safety standards;

   - The effective management of ageing of structures, systems and components (SSCs) is a key element of the safe and reliable operation of nuclear power plants.
   - This publication provides recommendations for managing ageing of SSCs important to safety in nuclear power plants and recommendations on key elements of effective ageing management.
   - Is intended for use by operators in establishing, implementing and improving systematic ageing management programmes for nuclear power plants.

   - This publication establishes the basic requirements in all the relevant areas associated with the safety of research reactors, including site evaluation, design, operation, decommissioning, regulatory oversight and the management system.
   - Provides recommendations on all important aspects of developing, formulating and presenting the OLCs and the operating procedures for research reactors.
   - Provides recommendations on fulfilling the basic requirements in all relevant areas associated with the safety of research reactors.
   - The guide is directed at both operating organizations and regulatory bodies.

   - Briefly described in section 2.1 ‘The management and organizational structure of the operating organization’, under
IAEA safety standards;

10. Safety Guide SSG-24, Safety in the Utilization and Modification of Research Reactors;
   - The objective of this Safety Guide is to provide recommendations on meeting requirements on the safety related aspects of the utilization and modification of research reactors, without undue radiation risks to site personnel, the public or the environment.
   - It provides recommendations only on the safety implications of the utilization and modification of research reactors.
   - It provides recommendations to the operating organization, to external users of a research reactor (i.e. research and experimental staff), technical support organizations and other persons involved in utilization and modification projects.

   - The purpose of this Safety Guide is to provide recommendations and guidance on the conduct of a periodic safety review (PSR) for an existing nuclear power plant.
   - It is intended for use by operating organizations, regulatory bodies and their technical support organizations, consultants and advisory bodies.
   - The review process described in this publication is valid for nuclear power plants of any age and may have a wider applicability (also for other nuclear facilities).

12. OSART Guidelines Section 3.1, Management, Organization and Administration;
13. OSART Guidelines Section 3.2, Training and Qualification;
14. BPTC Textbook Module 6, Deterministic Safety Assessment;
15. BPTC Textbook Module 7, Probabilistic Safety Assessment;
16. BPTC Module 11, Limiting Conditions for Operation;
17. BPTC Module 12, Plant Renewals, Modifications and Upgrades, Ageing;
18. BPTC Module 22, Human Performance.

### 2.3 Operational safety programmes

**Consideration of the objectives of nuclear security in safety programmes**

The operating organization ensures that the implementation of safety requirements and security requirements satisfies both safety objectives and security objectives.

The operating organization is responsible for managing the implementation of safety requirements and security requirements by ensuring close cooperation between safety managers and security managers, with the objective of minimizing risks. Security and safety are viewed as complementary, as many of the measures designed to
ensure one will also serve to ensure the other.

**Emergency preparedness**

The operating organization must establish the organizational structure and assign responsibilities for managing emergencies. The emergency plan is prepared to cover all activities within the responsibility of the operating organization to be carried out in the event of an emergency. This plan is coordinated with those of all other bodies, including public authorities, having responsibilities in emergency situations, and is submitted to the regulatory body. The emergency plan also includes arrangements for emergency situations involving a combination of non-nuclear and nuclear hazards (for example fires in the presence of significant radiation and contamination levels, or the presence of toxic or asphyxiating gases in conjunction with radiation and contamination), and takes into account the specific site conditions. Site personnel must be trained in the performance of their duties in an emergency. There must be exercises of the emergency plans, some of which will be witnessed by the regulatory body at suitable intervals. On some occasions these exercises include the participation of as many of the organizations concerned as possible. The plans are subject to review and updating in the light of experience gained.

Instruments, tools, equipment, documentation and communication systems that are used in emergency situations must be available and well-maintained in such a manner that they are unlikely to be affected or to be made unavailable by postulated accidents.

**Accident management programme**

The operating organization establishes an accident management programme for the management of beyond design basis accidents.

An accident management programme is established that covers the preparatory measures and guidelines that are necessary for dealing with beyond design basis accidents. This accident management programme is documented and periodically reviewed and revised as necessary. It includes instructions for utilization of the available equipment (safety related equipment as far as possible, but also conventional equipment) and the technical and administrative measures to mitigate the consequences of an accident. The accident management programme also includes:

- organizational arrangements for accident management,
- communication networks
- and training necessary for the implementation of the programme.

The arrangements for accident management provide the operating staff with appropriate systems and technical support in relation to beyond design basis accidents. Arrangements are made, as part of the
emergency plan, to expand the emergency response arrangements where necessary to include responsibility for long term actions.

**Radiation protection and management of radioactive waste**

In every nuclear power plant there must be a programme to ensure that, in all operational states, radiation exposure within the nuclear power plant or due to any planned release of radioactive material from the nuclear power plant is kept below prescribed limits and in accordance with the ALARA principle. The radiation protection function in the operating organization must have enough independence and resources to enforce and give advice on radiation protection regulations, standards, procedures and safe working practices.

Each individual has a personal responsibility for putting into practice the exposure control measures which are specified in the radiation protection programme. Consequently, particular emphasis is given to training all site personnel so that they are fully aware of both the radiological hazards and of the protective measures made available. Personnel who may be occupationally exposed to radiation must have their exposure measured, assessed and recorded. Dose records are kept as required and made available to the regulatory body. The radiation protection programme must provide for the medical surveillance of site personnel to ascertain their physical fitness and to give advice in cases of accidental overexposure.

The generation of radioactive waste, in terms of both activity and volume, must be kept to the minimum practicable by appropriate operating practices. The operating organization establishes and implements a programme to manage radioactive waste safely. The programme includes collection, segregation, treatment, conditioning, on-site transport and storage and dispatch of radioactive wastes.

The operating organization must establish and implement procedures for monitoring and controlling discharges of radioactive effluents and perform a safety analysis of radioactive discharges which demonstrates that the assessed radiological impact and the exposure of the general public are kept as low as reasonably achievable.

**Fire safety**

The operating organization must have fire safety arrangements based on a periodically updated fire safety analysis. Such an arrangement includes the application of the principle of defence in depth, the impact of plant modifications on fire-fighting, the control of combustibles and ignition sources, the inspection, maintenance and testing of fire protection measures, the establishment of manual fire-fighting capability and the training of plant personnel.

**Non-radiation-related safety**

The operating organization establishes and implements a programme
to ensure that safety related risks associated with non-radiation-related hazards to personnel involved in activities at the plant are kept as low as reasonably achievable.

**Non-radiation-related safety concerns hazards other than radiation-related hazards; this is sometimes referred to as industrial safety or conventional safety.**

Such a programme includes arrangements for:
- planning,
- implementation,
- monitoring,
- and review of the relevant preventive and protective measures.

It is integrated with the nuclear and radiation safety programme. All personnel, suppliers, contractors and visitors are trained. They also possess the necessary knowledge of the non-radiation-related safety programme and its interface with the nuclear and radiation safety programme. The operating organization provides:
- support,
- guidance
- and assistance for plant personnel in the area of non-radiation-related hazards.

**Operational experience feedback**

Operational experience at the plant is assessed in a systematic way. Similarly, the operating organization obtains and evaluates information from operational experience at other plants which provides lessons for the operation of their own plant. Exchange of experience and contribution to national and international organizations is very important.

Abnormal events with important safety implications are investigated to establish their direct and root causes. The results of the investigation are clear recommendations to plant management who take appropriate corrective action. Information is fed back to plant personnel.

**Operational experience feedback helps to maintain nuclear safety.**

Plant personnel should report all incidents and be encouraged to report near misses relevant to the safety of the plant.

There must be appropriate liaison between plant management and the organizations involved in the design (manufacturer, research organization, designer), with the aim of feeding back operating experience and of obtaining, if needed, valuable advice in case of equipment failures or abnormal events.
Data from operating experience is collected and retained for use as input to plant ageing management, residual life evaluation, probabilistic safety assessment and periodic safety review.

**IAEA safety standards and additional information**

1. Safety Requirements GS-R-2, Preparedness and Response for a Nuclear or Radiological Emergency; (under revision)
   - This publication covers the preparation and implementation of arrangements for responding to a nuclear or radiological emergency.
   - In such a case the response may involve many organizations. Therefore, in order to be effective, the response must be well co-ordinated and arrangements must be appropriately integrated.
   - This publication establishes requirements for common concepts and expectations, the clear allocation of responsibilities among all response organizations, agreements between these organizations, and arrangements for co-ordinating an integrated response.

   - This publication provides guidance for plant managers, operators, safety assessors and regulators to ensure that an adequate level of fire safety is maintained throughout the lifetime of an NPP.
   - It applies to new and existing nuclear power plants with thermal neutron reactors of the types in general use.
   - It covers a number of distinct elements which should be considered in the fire safety arrangements, such as the principle of defence in depth, the responsibilities of individuals, the training of plant personnel, manual firefighting capability, etc.

   - This publication provides recommendations to the regulatory body focused on the operational aspects of radiation protection and radioactive waste management in nuclear power plants.
   - It also provides useful information for senior managers in the licensee or contractor organization who are responsible for establishing and managing programmes for radiation protection and for the management of radioactive waste.
   - It gives general recommendations for the development of radiation protection programmes.
   - It deals with area classification, workplace monitoring and supervision, application of the principle of optimization of protection (ALARA), facilities and equipment.
   - It covers all the safety related aspects of the programme for management of radioactive waste at a nuclear power plant.
4. Safety Guide NS-G-2.11, A System for Feedback of Experience from Events in Nuclear Installations;
   - This publication provides guidance for all the organizations that are professionally involved in the nuclear industry, such as regulatory bodies, technical support organizations, operating organisation, etc.
   - It provides recommendations on all the main components of systems for the feedback of operational experience used in gathering relevant information on events and abnormal conditions that have occurred at nuclear installations throughout the world.
   - Briefly described in section 2.1 ‘The management and organizational structure of the operating organization’, under IAEA safety standards;
6. OSART Guidelines Section 3.1, Management, Organization and Administration;
7. OSART Guidelines Section 3.5, Technical Support;
8. OSART Guidelines Section 3.6, Operational Experience Feedback;
9. OSART Guidelines Section 3.7, Radiation protection;
10. OSART Guidelines Section 3.9, Emergency Planning and Preparedness;
11. BPTC Textbook Module 2, Radiation Protection in Nuclear Facilities;
12. BPTC Textbook Module 19, Waste Management.

2.4 Commissioning

The comprehensive commissioning programme is established to provide evidence that the nuclear power plant as constructed meets the design intent and complies with the safety requirements. The operating organization must 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 Operating Limits and Conditions (OLCs).

Commissioning is the process during which plant components, systems and structures are tested and placed in operation.

The authorizations and responsibilities for the commissioning process are clearly defined and delegated to the individuals performing the work. The interfaces between those groups involved in commissioning
(e.g. design, construction, contractors, commissioning and operations groups) must be clearly defined and properly controlled.

Operating procedures must be verified to ensure their technical accuracy and validated to ensure their usability with the installed equipment and controls as far as possible prior to loading fuel into the core. This is a continuous process during the commissioning phase. If possible, the operating procedures must be validated with the participation of the future operating personnel.

Prior to the initial core loading it is necessary to confirm all prerequisites regarding systems, equipment, documentation and personnel. These prerequisites must be clearly described and documented based on the safety analysis report and the existing regulatory requirements.

All functions of the operating organization are implemented at the appropriate stages during commissioning. These functions include the responsibilities of management, training of personnel, the radiation protection programme and waste management, management of records, fire safety, physical protection and emergency plans.

**IAEA safety standards and additional information**

   - This publication provides recommendations on how to meet the requirements of the commissioning programme; on organization and management; on testing and review procedures; and on the interfaces between the organizations involved in the commissioning activities, including the regulatory body.
   - It also deals with the control of changes in the commissioning programme and with the documentation required for and produced in commissioning.
   - The publication is mostly focused on activities performed at the plant site.
   - The publication is the revision of Safety Standards NS-G-2.9.

2. Safety Guide NS-G-4.1, Commissioning of Research Reactors;
   - This publication provides recommendations on meeting the requirements for the commissioning of research reactors.
   - It is intended for use by all organizations involved in commissioning.
   - This safety guide describes the safety objectives of commissioning, the tasks involved in accomplishing these objectives, the organization for commissioning that must be in place and the activities needed to perform the tasks, and the process of verifying that the objectives have been accomplished.
   - This guide is primarily intended for the commissioning of newly designed and constructed reactors; it is also suitable for the recommissioning of research reactors (e.g. after a period of
extended shutdown), and for the commissioning of new experimental devices and reactor modifications.

3. OSART Guidelines Section 3.10, Commissioning.

### 2.5 Plant operations

#### Operating instructions and procedures

All activities that may affect safety must be conducted in accordance with established procedures. A comprehensive administrative procedure must be established which contains the rules of development, elaboration, validation, acceptance, modification and withdrawal of operating instructions and procedures. Operating procedures are developed which provide comprehensive coverage of normal, abnormal and emergency conditions, in accordance with the policy of the operating organization and the requirements of the regulatory body. Responsibilities and lines of communication must be clearly set out in writing for situations in which the operating personnel discover that the status of the plant is not in accordance with operating procedures. Further instructions for writing the procedures for normal, abnormal and emergency conditions are given in IAEA publication NS-G-2.2.

#### Operation control rooms and control equipment

The operating organization ensures that the operation control rooms and control equipment are maintained in a suitable condition.

The habitability and good condition of control rooms is maintained by the operating organization. Where the design of the plant foresees additional or local control rooms that are dedicated to the control of processes which could affect plant conditions, clear communication lines are developed.

The emergency control room and the shutdown panel and all other safety related operational panels outside the control room are kept operable and free from obstructions, as well as from non-essential material that would prevent their immediate operation.

The alarms in the main control room are managed as an important feature in operating the plant safely. The plant information system is such that abnormal conditions are easily recognizable by the operators. Control room alarms are clearly prioritized. The operating organization has procedures in place for operators so that they can properly respond to alarms.

#### Material conditions and housekeeping

The operating organization develops and implements programmes to
maintain a high standard of material conditions, housekeeping and cleanliness in all working areas.

Administrative controls must be established to ensure that operational premises and equipment are maintained, well lit and accessible, and that temporary storage is controlled and limited. Equipment that is degraded is:

- identified,
- reported,
- and corrected in a timely manner.

**Chemistry programme**

The operating organization establishes and implements a chemistry programme to provide the necessary support for chemistry and radiochemistry.

The chemistry programme is developed prior to normal operation and is in place during the commissioning programme. The chemistry programme provides the necessary information and assistance for chemistry and radiochemistry to ensure:

- safe operation,
- long term integrity of structures, systems and components,
- and minimization of radiation levels.

Chemistry surveillance is conducted at the plant to verify the effectiveness of chemistry control in plant systems and to verify that all components important to safety are operated within the specified chemical limit values.

The chemistry programme includes chemical monitoring and data acquisition systems. System together with laboratory analyses provide chemical data and alarms for relevant chemical parameters.

The use of chemicals in the plant, including chemicals brought in by contractors, are kept under close control.

**Core management and fuel handling**

The operating organization is responsible and makes arrangements for all the activities associated with core management and on-site fuel handling to ensure the safe use of fuel in the reactor and safety during its movement and storage on site. The operating organization must prepare and issue specifications and procedures for the procurement, loading, utilization, unloading and testing of fuel and core components.

A fuelling programme is established in accordance with the design intent and assumptions. Core condition monitoring is carried out and the fuelling programme reviewed and modified as necessary.
Criteria must be established and procedures written for dealing with fuel and control rod failures to minimize fission and activation products in the primary coolant or in gaseous effluent.

**IAEA safety standards and additional information**

   - The objective of this Safety Guide is to provide guidance on the design of I&C systems important to safety in nuclear power plants.
   - Briefly described in section 2.2 ‘Management of operational safety’, under IAEA safety standards;
   - The purpose of this publication is to provide recommendations for core management and fuel handling at nuclear power plants.
   - It describes the safety objectives of core management, the tasks that have to be accomplished to meet the objectives and the activities undertaken to perform these tasks.
   - It also deals with the receipt of fresh fuel, its storage and handling and other core components, etc.
   - Briefly described in section 2.1 ‘The management and organizational structure of the operating organization’, under IAEA safety standards;
   - The purpose of this publication is to provide recommendations for core management and fuel handling at research reactors.
   - ‘Core management’ refers to those activities that are associated with fuel assemblies, management of core components and reactivity control.
   - ‘Fuel handling’ refers to the movement, storage and control of fresh and irradiated fuel.
   - It is intended for use by operating organizations, regulatory bodies and other organizations involved in the operation of research reactors.
   - The objective of this Safety Guide is to provide assistance in safe operation according to current international best practices for chemistry programmes.
   - The objective is also to provide recommendations on supporting the integrity of various barriers regarding the potential for corrosion of components, optimizing occupational radiation exposures in the plant and limiting releases of
radioactive material and chemicals to the environment.

2.6 Maintenance, testing, surveillance and inspection

The operating organization prepares and implements a programme of maintenance, testing, surveillance and inspection of those structures, systems and components which are important to safety. All these services must be of such a standard and frequency as to ensure that their level of reliability and effectiveness remains in accordance with the design assumptions and intent throughout the plant’s service life. The operating organisation must establish procedures for all maintenance, testing, surveillance and inspection tasks which are in accordance with established administrative procedures. The frequency of preventive and predictive maintenance, testing, surveillance and inspection is determined by their importance to safety, inherent reliability, potential for degradation and operational experience.

A comprehensive work planning and control system must be implemented to ensure that maintenance, testing, surveillance and inspection work is properly authorized, and carried out in accordance with procedures. The work control system ensures that plant equipment is only released from service for maintenance, testing, surveillance and inspection with the authorization of designated operations staff and in compliance with the OLCs.

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

Maintenance, testing, surveillance and inspection data must be recorded, stored and analysed. The analysis must confirm that performance is in accordance with design assumption and with expectations on equipment reliability.

IAEA safety standards and additional information

1. Safety Guide NS-G-2.6, Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants;
   - This publication provides recommendations and guidance for maintenance, surveillance and in-service inspection (MS&I) activities to ensure that all plant structures, systems and components (SSCs) important to safety are available to perform their functions in accordance with the assumptions and intent of the design.
   - It covers the organizational and procedural aspects of MS&I.
   - It also provides recommendations and guidance for preventive and remedial measures, including testing, surveillance and in-service inspection of SSCs to assure that they are capable of
performing as intended.

2. Safety Guide NS-G-4.2, Maintenance, Periodic Testing and Inspections of Research Reactors;
   - This publication provides recommendations for preparing and implementing programmes of maintenance, periodic testing and inspection.
   - The publication is intended for use primarily by operating organizations, regulatory bodies and other organizations involved in the operation of research reactors.
3. OSART Guidelines Section 3.4, Maintenance;
4. OSART Guidelines Section 3.5, Technical Support;
5. BPTC Textbook Module 13, Maintenance Programme;
6. BPTC Textbook Module 14, Surveillance Programmes.

2.7 Decommissioning

The operating organization must have in place arrangements for decommissioning the plant well in advance of the final shut-down. It is important to keep in mind the needs of decommissioning during the operational life of the plant. Experience from handling contaminated or irradiated structures, systems and components during maintenance or modification of the plant must be recorded in order to facilitate the planning of decommissioning. The safety analysis report must be revised, or an equivalent report prepared, to provide the safety justification during the various stages of decommissioning. The safety analysis report must be scrutinized to derive Operational Limits and Conditions (OLCs), surveillance and inspections during decommissioning. As a given decommissioning stage is entered, the relevant OLC requirements must be implemented.

IAEA safety standards and additional information

1. Safety Requirements WS-R-5, Decommissioning of Facilities Using Radioactive Materials; (under revision)
   - The objective of this publication is to establish the basic safety requirements that must be satisfied during the planning and implementation of decommissioning.
   - The publication deals with all phases of decommissioning and also establishes requirements for the period after the permanent planned shutdown of a facility.
   - This publication applies to all types of facility.
2. Safety Guide WS-G-2.1, Decommissioning of Nuclear Power Plants and Research Reactors; (under revision)
   - The objective of this publication is to establish the basic Safety requirements for the decommissioning of nuclear power plants and research reactor facilities.
   - It provides guidance to national authorities, including regulatory bodies, and operating organizations to ensure that the decommissioning process for nuclear power plants and research reactors is conducted in a safe and environmentally
acceptable manner.
- Publication mainly addresses the radiological hazards resulting from the activities associated with the decommissioning.

3. BPTC Textbook Module 18, Decommissioning.

### 2.8 Questions

1. Who has prime responsibility for operational safety?
2. Who is responsible for independent supervision of a nuclear power plant?
3. To whom does the operating organization report abnormal events?
4. State an important reason for collecting data from operational experiences.
5. What is included in fire safety arrangements?
6. What is the purpose of the emergency preparedness programme?
7. When does the quality assurance programme form integral part of activity in a nuclear power plant?
8. The systematic use of quality assurance is important in which areas?
9. Why is physical security and physical protection of a nuclear power plant necessary?
10. Who has prime responsibility for qualification of the nuclear power plant personnel?
11. What consideration should encourage training programme?
12. What is the role of the operating organization during commissioning?
13. How are the operational limits and conditions classified?
14. What kind of activities must be conducted in accordance with procedures?
15. Why are the data from maintenance, testing, surveillance and inspection activities recorded?
16. What is included in the term plant modifications?
17. What principle is used in radiation protection and radioactive waste management and what does it mean?
18. What points should be taken into account when a periodic safety review is performed?
3 EXPECTATIONS FOR OPERATIONAL SAFETY

Learning objectives
After completing this chapter, the trainee will be able to:
1. Define the administrative and functional structure of the operating organization.
2. Describe an appropriate training and qualification programme for safe operation of a nuclear power plant.
3. Define the main function of operations.
4. Identify the purpose of maintenance and maintenance programmes.
5. List all on-site activities which are covered by technical support.
6. Describe a well-implemented operational experience programme.
7. Describe the radiation protection programme and state its purpose.
8. Describe the purpose of chemistry policy for a nuclear power plant.
10. Describe the purpose of decommissioning.

3.1 Management, organization and administration

The organizational structure must support safe, reliable and effective performance and control of all nuclear power plant (NPP) activities. The organization provides the administrative and functional structure that determines where people are assigned, what they are to do, and how they are expected to accomplish their tasks. Policies, procedures and standards provide administrative controls and management direction to implement the organizational structure, to conduct all power plant activities and ensure safe operation of the power plant. The organisational structure establishes formal relationships and lines of communication. The responsibilities and authorities for accomplishing assigned tasks must be clearly defined and communicated within the established organizational structure.

Management monitoring and assessment activities are integral parts of the administrative system.

At the power plant a sound safety management system must be established as an integral part of the overall management system. The safety management system is needed to promote a strong safety culture and achieve and maintain good safety performance.

The management, organization and administration (MOA) section of the relevant guidelines includes NPP management practices. This
section also includes the quality assurance programme, the industrial safety programme, and the document and records management which are also important elements of NPP management and contribute the safe operation.

**Organization and administration**

The operating organization must establish an organizational plan that sets out the general policies, lines of responsibility and authority, etc., needed to run the nuclear power plant. When some critical plant personnel leave the workforce, management must have plans for replacing them with competent people.

The plant's documented organizational structure describes the staffing arrangements within the categories of direct line operating personnel and supporting personnel. Functional responsibilities, levels of delegated authority and lines of internal and external communication for safe operation of the plant in all operational states must be clearly defined in writing. The extent of those support functions which are self-sufficient or dependent upon services from outside must be shown by means of functional organizational charts. These charts must also include personnel resource allocations and specify the duties and responsibilities of key personnel. If there is a transfer of responsibility, it is essential that it is clearly defined and understood.

For safe and efficient operation of the plant managers must have adequate financial and manpower resources and facilities. Qualified spares, materials and equipment must be in the stockpile needed for timely execution of safety-related activities. The management system is supported by a well-established human resources management programme, a well-established performance appraisal system, and a promotion and succession-planning system that takes into account safety culture. Individuals must be physically and mentally fit to perform their jobs in a safe manner.

All activities that may affect safety must be performed by suitably qualified and experienced persons. The nuclear power plant is staffed with competent managers and a sufficient number of qualified personnel. All personnel must have a proper awareness of the technical and administrative requirements for safety. Staff performance appraisals must also include the safety culture.

Support activities carried out by contractors must be in accordance with the applicable standards of quality and safety policy. Requirements relating to the quality and competency of contractor staff and their work product must be at the same standard as for the activities carried out by plant staff.

**Contractors are subject to the same applicable standards of quality and safety policy.**
The operating organization must allow access to the plant and documents so that the regulatory body may perform its work.

**Management activities**

Management must establish and clearly communicate high standards of performance to promote excellence in the conduct of all power plant activities. In particular, senior management is committed to a clear statement of quality and safety policy.

Management must actively promote and frequently reinforce corporate policies, safety goals and objectives. Suitable goals and objectives must be set even at departmental level to support the goals of the plant management. Where it is reasonable, the goals and objectives must be quantified and stated in terms that allow measurement of progress and clear determination of achievement.

Supervisors and managers must understand their role and responsibilities and the reasons for required policies. Plant staff must have a mechanism to report safety concerns to management. Staff must have a similar mechanism with which can report safety concerns to an independent body (e.g. the regulator). Senior level managers must be accessible and respond to personnel suggestions. Managers are routinely accessible and available to assess and discuss the conduct of work and compliance with management objectives.

To ensure safe and effective methods of working and uniformity of performance, the nuclear power plant must have administrative procedures, rules and instructions which cover all aspects of plant operation and are applicable to all personnel on site.

Probabilistic safety assessments (PSAs) are periodically performed to identify potential plant vulnerabilities and understand the relative risk contribution of particular design and operational features. Resulting from the availability of PSA studies, there must be a desire to use them to enhance plant safety and to operate the plant more efficiently. PSA has proved to be an effective tool for this purpose. However, any PSA that is to be used for such a purpose must have a credible and defensible basis.

**Management of safety**

The organization's safety management system is generally considered to be an integral part of its overall management system.

The safety management system is applied in a coherent manner, with integral management of safety, health, environmental quality and economic matters.

A policy on safety is developed by the operating organization and applied by all site personnel. The safety policy demonstrates the organization's commitment to high safety performance. The operating
organization ensures that adequate resources are available to implement the safety policy.

All functions in the operating organization must encourage and support sound safety management practices at the highest levels of corporate and plant management. Managers must demonstrate their commitment to safety as a top priority.

The risks associated with any operating activity at the plant are systematically evaluated and measures are taken to eliminate or mitigate any risks identified.

The operating organization demonstrates a commitment to achieving improvements in safety wherever it is reasonably practicable to do. For achieving higher safety performance, the organization must have well-defined programme of improvement with clear objectives and targets.

Plant operation must be comprehensively monitored to ensure licence accountability and to evaluate the goals and objectives established for safe operation of the plant.

For measuring progress in achieving the safety goals and objectives, the operating organization must establish and regularly assess performance indicators. The results must be communicated to staff and used to derive corrective actions.

**Quality assurance programme**

The operating organization must develop, implement and maintain a quality policy and a quality assurance (QA) programme. The QA programme is a tool for management to verify or confirm that the requirements established within the organization are being achieved. This programme includes details of how work is to be managed, performed and assessed. It includes the organizational structure, functional responsibilities, level of authority and interfaces for those managing, performing and assessing the adequacy of the work.

The operating organization is responsible for the establishment and implementation of the overall QA programme. If it delegates the work of establishing and implementing all or part of the overall programme, it retains responsibility for the effectiveness of the programme in all circumstances.

Quality assurance requirements apply to activities such as operations, maintenance and procurement of replacement items, tests or experiments, changes of configuration and plant modification, which may be undertaken by other units of the operating organization or by external agencies. It remains the responsibility of plant management to ensure that arrangements are in place to control all activities affecting quality.
Safety issues are the fundamental consideration in the identification of items, services and processes to which the QA programme applies. A graded approach based on the relative importance to safety of items, services and processes is used. It reflects a planned and recognized difference in the applications of specific quality assurance requirements.

Independent assessments must be conducted on behalf of management to measure the effectiveness of management processes and the adequacy of work performance, to monitor item and service quality and to promote improvement.

**Industrial safety programme**

The operating organization must have a general policy to ensure the industrial health and safety of personnel on site is satisfactory. All elements of this policy are documented in a plant safety manual, while details are included in implementing procedures.

The industrial safety programme must be known, understood and adhered to by all personnel on site. Senior management is committed to industrial safety and the line supervisors must have the authority and responsibility to ensure good industrial safety performance. A risk analysis must be performed prior to any activity.

**Document and records management**

A document and records management system must be established to ensure the appropriate keeping of all documents relevant to the safe and reliable operation of the plant, including design documents, commissioning documents, documents related to the operational history of the plant, as well as general and specific procedures. Control of documentation is done in a consistent, compatible manner throughout the plant and the operating organization. This includes preparation, change, review, approval, release and distribution of documentation.

The records system ensures that records are specified, prepared, authenticated and maintained as required by applicable administrative procedures in accordance with the QA requirements. Information sources are integrated, when appropriate, to improve the accuracy, timeliness and availability of the information.

A suitable records storage system must be in place to ensure safe conservation and easy accessibility of all documents and records necessary to operate the plant.

**IAEA safety standards and additional information**

1. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
2. IAEA, Safety Guide NS-G-2.2, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants;
3. IAEA, Safety Guide NS-G-2.3, Modifications to Nuclear Power Plants;
5. IAEA, Safety Guide NS-G-2.8, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants;
6. IAEA, Safety Series No. 50-C/SG-Q, Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations (Code and Safety Guides Q1 - Q14);
7. IAEA, Safety Series No. 75-INSAG-4, Safety Culture;
8. IAEA, INSAG Series No. 10, Defence in Depth in Nuclear Safety;
9. IAEA, INSAG Series No. 12 (INSAG-3 Rev. 1), Basic Safety Principles for Nuclear Power Plants;
10. IAEA, INSAG Series No. 13, Management of Operational Safety in Nuclear Power Plants;
11. IAEA, INSAG Series No. 14, Safe Management of the Operating Lifetimes of Nuclear Power Plants;
12. IAEA, INSAG Series No. 15, Key Practical Issues In Strengthening Safety Culture;
13. IAEA, INSAG Series No. 17, Independence in Regulatory Decision Making;
14. IAEA, INSAG Series No. 18, Managing Change in the Nuclear Industry: The Effects on Safety;
15. IAEA-TECDOC-744, OSART Guidelines;
16. IAEA-TECDOC-1321, Self-Assessment of Safety Culture in Nuclear Installations: Highlights and Good Practices;

3.2 Training and qualification

Nuclear power plants are required to be staffed by an adequate number of highly qualified and experienced personnel, if high safety standards are to be achieved and maintained. Appropriate training and qualification programmes must be established and kept under constant review at the plant, to set up and maintain a high level of personnel competence. The operating organization has the responsibility of ensuring that all plant personnel must receive appropriate training and only personnel with suitable qualifications are assigned job functions at the plant. During employment, qualifications are maintained by participation in continuing training programmes.

Training policy and organization

The operating organization formulates an overall training policy. The training policy must be known, understood and supported by all
persons concerned. A training plan is prepared on the basis of the long term needs and goals of the plant. A system to identify the training needs of all staff must be in place. Training needs must be reviewed and revised to take account of organizational changes and changes in plant and processes.

The plant manager is responsible for the qualification of plant staff and must support the training organization with the necessary resources including staffing and facilities. Succession planning is an established practice in the training organization. The training organization is responsible for assisting the plant manager in establishing, verifying and maintaining the competence of plant staff. Line managers and supervisors are accountable for the qualification of their personnel and involved in defining the training needs and ensuring that the training provided reflects operating experiences. Production requirements must not interfere with the conduct of training programmes.

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

Persons performing functions important to safety must be required to hold a formal authorization.

**Quality of training programmes**

Performance based programmes for initial and continuing training must be developed and put in place for each major group of personnel. The content of each programme is based on a systematic approach, such as job and task analysis, ensuring the necessary knowledge and skills are incorporated. Training programmes promote a culture which helps to ensure that issues of safety receive the attention that they warrant. Training programmes for most NPP positions include periods of formal training in the classroom intermixed with intervals of simulator, or laboratory, or workshop training, and should include practical training in the plant. Training is to be conducted and evaluated in the working environment by qualified, designated individuals.

For each major group of personnel initial and continuing training must be developed.

The adequacy of all training programmes must be periodically reviewed and assessed by both plant management and the training staff. This includes evaluation of the competence of graduates of the training programmes in the workplace and adjustment of their training programmes as necessary. Design of the programme must allow updating when changes in the tasks, plant systems or procedures are made.
Training programmes for control room operators and shift supervisors

The training and qualification programme for control room operators (CROs) and shift supervisors (SSs) must develop and improve their competence to operate the controls of a nuclear power plant. Their training programme should develop and maintain relevant knowledge and skills to ensure that they are able to:

- Monitor and control the status of plant systems in accordance with the relevant rules, operating instructions, technical specifications and administrative procedures;
- Conduct all operations in a safe and reliable manner, without causing excessive thermal or mechanical loads to plant equipment;
- Take correct actions in response to various abnormal conditions, and bring the plant to a safe condition, including shutdown, whenever needed.

The training programmes also include a broad knowledge of the fundamentals to provide a basis for understanding the operation of systems and integrated plant operations, and to diagnose system/component problems.

Training programmes for field operators

The field operator training and qualification programme must develop, maintain and improve the knowledge and skills necessary to operate equipment outside the control room, as directed by the control room staff. Their training programme must be similar to the programme for control room operators but it must emphasize practical work on specific topics. Well trained field operators are able to:

- Monitor equipment performance and status in the field and recognize any deviations from normal conditions;
- Conduct all field operations in a safe and reliable manner, without causing unacceptable risks to the plant;
- Detect and properly respond to plant conditions with the goal of preventing or, as a minimum, of mitigating unanticipated plant transients.

Training programmes for maintenance personnel

The training and qualification programme for maintenance personnel must develop and maintain or improve the knowledge and skills necessary for carrying out preventive and predictive maintenance, repairs and plant modifications. Training programmes for maintenance personnel include the plant layout and the general features and purposes of plant systems, quality assurance and quality control, maintenance procedures and practices, including surveillance and inspections, and special maintenance skills. An appropriate emphasis on safety culture is included in all aspects of training for maintenance personnel. It is very important that they are aware of the potential safety consequences resulting from technical or procedural errors. Experience of faults and hazards caused by errors in maintenance
procedures and practices at the NPP or at other plants must be reviewed and incorporated into training programmes as appropriate.

**Training programmes for technical plant support personnel**

The training and qualification programmes for technical support personnel must be established to develop and maintain the knowledge and skills of technical personnel to support safe and reliable plant operation. Technical support personnel acquire a knowledge of plant systems and an understanding of operational methods. These personnel should have a knowledge of the operational features of the plant and preferably possess 'hands on' experience. Dependent on the specific technical support groups, the appropriate training programmes cover such subject areas as reactor physics and core management, chemistry, radiation protection, etc.

**Training programmes for management and supervisory personnel**

The plant must have a management development programme to ensure that an adequate number of experienced and qualified staff are available to fill any managerial or supervisory position. Training programmes for management and supervisory personnel emphasize the concept and practices of safety culture. These programmes emphasize the special problems of managing an NPP, with the exceptional demand for safety and the need for familiarity with emergency procedures.

Such programmes must give a thorough understanding of the relevant standards, rules and regulations. They also give a good overall knowledge of the plant and its systems. Managers and supervisors with responsible positions in the emergency preparedness organization are specially trained for their emergency duties. Special attention is given to gaining the benefits of operational experience feedback and root cause analysis for events that are generic or occur frequently at the plant. The training programmes also include courses and seminars on management and supervisory skills, coaching and mentoring, decision making, self-assessment techniques, root cause analysis, team training, and communications. Managers and supervisors also attend continuing training in their areas of responsibility in order to maintain current technical knowledge and to be able to supervise the training of their staff.

**Training programmes for training group personnel**

All training department staff, simulator and technical support engineers, technicians and instructors must be given training commensurate with their duties and responsibilities. Training instructors are technically competent in their assigned areas of responsibility and have credibility with the trainees and other plant personnel. They must understand all aspects of the content being taught and the relationship of that content to overall plant operation. In addition, instructors must be familiar with the basics of adult learning.
and have adequate instructional and assessment skills. Instructors must maintain their technical and instructional competence by secondment or attachment to operating plant on a regular basis, and by continuing training. Personnel must also be properly trained in matters concerning safety management and safety culture, the regulatory requirements and quality assurance.

**General employee training**

All new employees starting work at nuclear power plants must be introduced to the organization and their work environment in a systematic and consistent manner. General employee training (GET) programmes give new employees a basic understanding of their responsibilities and safe work practices, the importance of quality programmes and of following procedures, and the practical abilities to protect themselves from hazards associated with their work. Hands-on training in radiation protection actions must be provided to all who work in radiologically controlled areas. The basic principles of safety culture must be taught to all employees. Refresher training on GET topics must be periodically provided.

**IAEA safety standards and additional information**

1. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
2. IAEA, Safety Guide NS-G-2.2, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants;
4. IAEA, Safety Guide NS-G-2.6, Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants;
5. IAEA, Safety Guide NS-G-2.8, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants;
6. IAEA, INSAG Series No. 13, Management of Operational Safety in Nuclear Power Plants;
7. IAEA, INSAG Series No. 15, Key Practical Issues In Strengthening Safety Culture;
8. IAEA, INSAG Series No. 18, Managing Change in the Nuclear Industry: The Effects on Safety;

**3.3 Operations**

Operations involve activities that supervise the operating group which controls safe plant operation. The main function of operations is to run the plant safely and efficiently while adhering to approved procedures, operational limits and conditions (OLCs) and other regulatory requirements. The operating group has a direct impact on reactor operations and its associated components and systems through its conduct of operations. While the structure of the group varies
according to the specific plant or utility, the group is normally composed of shift crews and supporting staff (during office hours) and is usually managed by the head of operations. Outside office hours the shift supervisor manages plant operations on each shift. During off-hours the shift supervisor maintains the authority of the plant manager. In addition to this, for the purpose of defining responsibilities in these guidelines, the term operations covers operation facilities, operator aids, work authorization, fire protection and accident conditions.

The main function of operations is to run the plant safely and efficiently.

**Organization and functions**

The organization and functions of the direct operating group must ensure that the nuclear power plant is operated safely and conservatively under all operational states and accident conditions. This also includes preparation to deal with severe accident conditions.

The organization, and the number and qualifications of operations personnel must be sufficient for the safe and reliable operation of the plant.

The responsibilities and authorities of the direct operating group must be clearly defined and understood by all personnel concerned.

The operations goals and objectives must be written and defined within the framework of plant policies and be well understood by operating personnel. Nevertheless nuclear safety has an overriding priority.

Plant management must be clearly committed to nuclear safety in plant operations. The frequent presence of management ‘on tour’ in the plant demonstrates this commitment.

**Operations facilities and operator aids**

The facilities and equipment used by the operating staff must be well maintained and adequate to support safe and reliable operation of the plant. It is important that the plant has a programme to control operator aids on the plant. This programme ensures reliable communications, well identified and labelled equipment, free of defective or unavailable items, good environmental conditions at the plant, clear and always friendly information systems, and adequate and well maintained supportive equipment.

**Operating rules and procedures**

Operating personnel must operate the plant safely and reliably while keeping the plant's operation within the OLCs, in accordance with the policy of the operating organization and the requirements of the
regulatory body. Comprehensive legible operating procedures must be provided for the operators.

Procedures are developed for normal operation to ensure that the plant is operated within the OLCs. Either event-based or symptom-based procedures must be developed for anticipated operational occurrences and design basis accidents, as well as emergency operating procedures or guidance for managing severe accidents (beyond the design basis).

The guidance provided in procedures must be clear, concise, verified for its accuracy and validity, and appropriate to enable trained operators to perform their activities.

All procedures must be properly approved by plant management, controlled by established procedures, and implemented in a timely manner. Operators are appropriately trained in the relevant procedures, including changes to existing procedures or new procedures.

An appropriate surveillance programme must be established and implemented to ensure compliance with the OLCs, and its results are evaluated and retained.

At a multiple unit site, documents and procedures must be located at each unit.

**Conduct of operations**

Operations personnel must be cognizant of and have control over the status of plant systems and equipment. The shift supervisor must be informed of all plant activities affecting the status of systems and components. All activities and information such as performance and results of surveillance tests and maintenance works must be routed via the supervisor or his delegate for final approval. Similarly, operators must be kept informed of plant status.

A policy must be in place that gives direction to the operators on procedural rules and requirements on how a procedure must be used. This policy includes directions for when procedures are to be used as general guidance, are to be followed step-by-step, or need to be signed off for each step. The policy also includes directions as to when a procedure must be physically at the job site, and what actions are to be taken when procedures conflict or are inadequate. Deviation from these procedures requires approval at a level appropriate to their safety significance. Procedure users must be encouraged to provide feedback to those writing procedures.

The operating department’s policies and procedures reflect a conservative safety culture approach to operations. Managers and supervisors must demonstrate and require a conservative approach toward activities affecting the reactor core and safety systems.
Control room activities must be conducted in a business-like and professional manner. An atmosphere conducive to safe and reliable operation must be maintained. Administrative duties assigned to control room operators must not interfere with their ability to monitor plant parameters and conduct other operational activities. Control room access is limited to persons on official business only.

The shift crews routinely monitor the condition of systems and components and make the appropriate records. Important information on plant status and the relevant operating occurrences must be adequately logged. The operational personnel conduct regular plant tours to ensure that the status of equipment is evaluated appropriately and abnormal conditions identified. If deficiencies are noted during tours, the operational personnel report them or take appropriate actions to correct them.

The shift turnovers must be carried out in accordance with the formal procedure. These procedures identify the persons involved, their responsibilities, the locations and the conduct of shift turnovers, methods of reporting plant status, including provisions for special circumstances such as abnormal plant status and staff unavailability.

Effective reviews must be conducted after a reactor trip or unplanned shutdown to evaluate the causes of the trip and the corrective measures implemented.

A formal communication system must exist for the transmission of orders and for the transfer of information related to the reliable and safe operation of the plant.

**Work authorizations**

Work conducted at the plant is planned, analysed and executed in a manner that is consistent with the requirements of plant operations. A comprehensive work planning and control system is implemented to ensure that maintenance, testing, surveillance and inspection work is properly authorized and is carried out in accordance with established procedures. The work control process must be integrated into all work groups. By supporting this process operations will be better able to analyse risk when equipment is inoperable and decrease the time important equipment is not available due to inappropriate scheduling of maintenance.

The operations group has the responsibility to assist maintenance in the planning and execution of work on plant components and systems to ensure that equipment reliability and availability is maximized.

Planned or foreseen work must go through the same safety review process to evaluate risk as work in a planned schedule.
Planning of work, outages, modifications and tests must be well coordinated to assure that the plant remains in a safe condition. Better planning and work control also means that control room operations staff, maintenance technicians, system engineers, radiation protection personnel and planners are better able to coordinate their activities. The work management system ensures that operational tasks are identified, prioritized and correctly executed. Suitable and sufficient assessments of the risks to health and safety arising from particular activities need to be carried out. The results of risk assessment need to be incorporated into the documentation of the permit to work system.

**Fire prevention and protection programme**

The operating organization must establish and implement a comprehensive programme for fire prevention and protection to ensure that measures for all aspects of fire safety are identified, implemented, surveyed and documented throughout the entire lifetime of the plant. It is expected that the programme includes at least the following:

- Control procedures for combustible materials and ignition sources;
- Inspection, maintenance, surveillance and testing of fire protection measures;
- Manual firefighting capability;
- Emergency plans, including liaison with any off-site organizations that have responsibilities in relation to firefighting;
- Integration of plant fire safety arrangements and liaison between the parties involved;
- Review of plant modifications to evaluate their effects on fire safety;
- Training in fire safety and emergency drills;
- Impact of plant modifications on fire safety;
- Periodic updating of the fire hazard analysis.

The responsibilities of site staff involved in the establishment, implementation and management of the programme for fire prevention and protection, including arrangements for any delegation of responsibilities, must be identified and documented. The documentation identifies the posts, specific responsibilities, authorities and chain of command for personnel involved in fire safety activities. The plant management establishes an on-site group with the specific responsibility for ensuring the continued effectiveness of the fire safety arrangements.

Plant personnel engaging in activities relating to fire safety must be appropriately qualified and trained so as to have a clear understanding of their specific areas of responsibility and an appreciation of the potential consequences of errors. General training relative to fire hazards, flooding, secondary effects of fires and fire zone protection must be provided to plant personnel.
Periodically, drills and exercises must be conducted to confirm the fire prevention and protection programme's implementation and effectiveness. Records must be maintained of all exercises and drills. Full consultation and liaison must be maintained with any off-site organizations that have responsibilities in relation to firefighting.

**Management of accident conditions**

Arrangements and procedures must be in place which address the actions necessary following accident conditions at the plant.

The organization and administration of the direct operating group must ensure that the nuclear power plant can be controlled under accident conditions. The shift supervisor must have prompt support from the technical staff while managing accident conditions (all kinds of accidents). An additional organizational structure is established to take over the responsibility for long term actions to mitigate effects on the environment, when the conditions exceed specific limits.

Under extreme situations the operator may be required to deviate from OLCs. The plant has clear written directions addressing under what circumstances the OLCs may be intentionally deviated from, what permission is necessary prior to the action, and any notifications to plant staff or regulators that are required before or after the deviation occurs.

Adequate training and frequent drills using the emergency operating procedures and emergency plan procedures must be carried out. The members of the operating staff receive instruction in the analysis of accidents beyond the design basis and severe accidents as part of their training programme. The training of plant operators ensures their familiarity with accidents.

The emergency staff and the supporting groups must be trained in performing appropriate, pre-planned actions. All the training is repeated at sufficiently frequent intervals and reinforced through drills involving the full exercise of all emergency team members under conditions that are as realistic as possible.

**IAEA safety standards and additional information**

1. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
2. IAEA, Safety Guide NS-G-2.1, Fire Safety in the Operation of Nuclear Power Plants;
4. IAEA, Safety Guide NS-G-2.3, Modifications to Nuclear Power Plants;
6. IAEA, Safety Guide NS-G-2.8, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants;
7. IAEA, Safety Series No. 50-C/SG-Q, Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations (Code and Safety Guides Q1 - Q14);
8. IAEA, INSAG Series No. 13, Management of Operational Safety in Nuclear Power Plants;
9. IAEA, INSAG Series No. 15, Key Practical Issues In Strengthening Safety Culture;
10. IAEA, Safety Report Series No. 11, Developing Safety Culture in Nuclear Activities.

3.4 Maintenance

All nuclear installations must be regularly inspected, tested and maintained in accordance with approved procedures. Maintenance ensures that components, structures and systems continue to be available and to operate as intended, and that they retain their capability to meet the design objectives and the requirements of the safety analysis. The operating organization must prepare and implement a programme of maintenance, testing, surveillance and inspection of those structures, systems and components which are important to safety.

**Maintenance covers in-service inspection, spare parts, materials and outage management.**

**Organization and functions**

The goals, objectives and priorities of the maintenance department must be defined to be consistent with the plant policies and objectives. Maintenance strategies are developed to address both short and long term issues. Effective and high quality maintenance programmes must be encouraged by senior management. Feedback from performance results is used in accountability reviews and in establishing goals and objectives for subsequent planning periods.

The organization and administration of the maintenance department must ensure the efficient and effective implementation and control of maintenance activities. The organization and staffing of the maintenance department, as well as the responsibilities of the different units and staff in maintenance, are defined and communicated such that all personnel concerned understand them. Good coordination among different maintenance groups (mechanical, electrical, instrumentation and control, and civil), and with operations and supporting groups must be established.

The organization, qualifications and number of maintenance personnel must be sufficient for the maintenance performed during the operation
of the plant. During an outage work can be performed by the plant's staff and by contractors under supervision. Contractor personnel must be subject to the same criteria as plant personnel. Good initial and continuing training must be implemented.

An emerging trend in plant maintenance and support is the increased employment of contractors to replace traditionally plant-based personnel. Whilst this policy has financial benefits for the utility, it often comes at the expense of safety as a result of the lower standards followed by contractors. The policy of relationships with contractors falls within the scope of safety culture development. This ensures that the primary responsibility of the utility or plant regarding safety and monitoring is not diluted and fosters the quality factor in the contractors' activities. Therefore, emphasis must be placed on the quality and safety of work done by the contractor. Contractors must receive the same attention and training in safety culture as utility staff.

**Maintenance facilities and equipment**

Working facilities must provide sufficient space and equipment to perform maintenance activities safely and efficiently. Maintenance facilities must be clean and orderly. Maintenance tools and equipment must be maintained in good repair. Lifting, loading and transport equipment must be available and there must be provisions for auditing this type of equipment.

Contaminated tools and equipment must be used and stored in a manner which prevents the spread of contamination. Work on contaminated equipment is controlled in order to minimize the radiation dose. Remote controlled equipment must be available for work in high radiation areas where it has the potential to decrease radiation dose at reasonable cost.

In addition to the special equipment essential for maintenance, the plant management provide special equipment where this could significantly reduce exposure or enhance safety, and also provide adequate training in its use.

Measurement and test equipment must be controlled to assure its accuracy and traceability. Chemicals and flammable materials must be stored appropriately.

**Maintenance programmes**

Comprehensive maintenance programmes must optimize the safe and reliable performance of plant systems and components over the lifetime of the plant. They are established for in service inspection, plant ageing and predictive, preventive and corrective maintenance.

These programmes must be fully integrated with plant operation and modification activities. They are routinely reviewed and updated, as required, to take into account on-site and off-site operating experience.
and modifications to the plant or its operating regime. Risk assessment techniques can also contribute to determining maintenance and inspection requirements.

The power plant must establish a programme that takes into account the plant equipment ageing process through the various activities of operation, surveillance and maintenance.

Preventive maintenance (PM) minimizes the potential for breakdown (corrective maintenance) of important equipment by the early detection and correction of equipment degradation. PM activities must be scheduled and carried out according to a defined programme.

Predictive maintenance activities are used to monitor the condition of installed equipment and systems where appropriate. The results of predictive maintenance activities and surveillance tests must be properly trended to promote the complete effectiveness of preventive maintenance and lifetime management programmes.

The corrective maintenance programme must provide for effective reporting and timely correction of equipment degradation.

An in-service inspection programme must be established to examine systems and components of the plant for possible deterioration. On this basis it can be evaluated whether they are acceptable for continued safe operation of the plant or whether remedial measures must be taken. An in-service inspection programme is implemented in accordance with plant policy, regulating requirements and OLCs.

Recently in the nuclear industry as a response to economic pressures there are initiatives to improve efficiency and reduce costs. In the maintenance area this may lead to increases in the time periods between maintenance or inspection outages to improve capacity factors, and to shortening maintenance and refuelling outage times for the same reason. These initiatives must be managed in such way that possible detrimental effects on the quality and effectiveness of the maintenance programmes are avoided.

**Procedures, records and histories**

Maintenance procedures and other work-related documents must identify preconditions and precautions, provide clear instructions for work to be done, and must be used to ensure that maintenance is performed in accordance with the maintenance strategy, policies and programmes. The procedures are normally prepared in co-operation with the designers, the suppliers of plant and equipment, and the personnel conducting activities for quality assurance, radiation protection and technical support. They must be technically accurate, properly verified, validated, authorized and periodically reviewed.

Priority must be given to amending and updating procedures in a
timely manner. A mechanism must be implemented which enables users to feedback suggestions for the improvement of procedures.

Maintenance instructions issued to craftsmen must be compiled in accordance with quality assurance requirements. They must also point out the risk impact of the work on nuclear and personnel safety, identify the countermeasures to be taken and specify the post maintenance/modification testing required. The required level of skill and the procedures to be used must be stated. Routine activities involving skills that qualified personnel usually possess may not require detailed step-by-step instructions; nevertheless they must be subject to control by means of general administrative procedures.

**Human factors and the ALARA principle must be considered in the preparation of maintenance instructions.**

The plant maintenance history must be used to support maintenance activities, upgrade maintenance programmes, optimize equipment performance and improve equipment reliability. Appropriate arrangements are made for orderly collection and analysis of records and production of reports on maintenance activities. Maintenance history records must be easily retrievable for reference or analysis.

**Conduct of maintenance work**

Maintenance must be conducted in a safe and efficient manner to support plant operation. Personnel must exhibit competence and professionalism, which result in quality workmanship when performing assigned tasks. Personnel must also demonstrate a questioning culture before, during and after the work is completed. The programmes and documentation support this culture.

Work is always performed in accordance with policies and procedures and so as to be consistent with ALARA and waste minimization principles.

Maintenance personnel must be attentive to identifying plant deficiencies and responsive to correcting them with the goal of maintaining the reliability and availability of equipment and systems.

Managers and supervisors must routinely observe maintenance activities to ensure adherence to plant policies and procedures.

**Material conditions**

The material condition of the plant must be maintained in such a way that its safe, reliable and efficient operation can be ensured.

**Work control**

A comprehensive work planning and control system that considers defence in depth must be used to ensure that work activities are
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properly identified, prioritized, authorized, scheduled and carried out in accordance with appropriate procedures and completed in a timely manner. The work planning system maintains the high availability and reliability of important plant systems. Outage planning is integrated into the work control process.

Effectiveness of the work control process must be monitored via appropriate indicators and corrective action taken when required. Plant defects must be tracked to completion and records kept of work performed. These records are accessible for review when necessary. The work control process must contain an effective operational feedback system and a systematic analysis of root causes of rework or repetitive failures. Work scheduling must allocate parts, materials, resources and expertise at the time appropriate for completion of the preventive and corrective programmes and make provision for adequate post-maintenance testing.

Improved planning and work control can increase the productivity of plant maintenance, which, in turn, can lead to a reduced maintenance backlog. This is likely to decrease the number of equipment problems with a beneficial effect in reducing the number of plant events and challenges to safety systems.

Confirmed delays and deviations from the work schedule are reviewed and appropriate action is taken.

**Spare parts and materials**

Materials management must ensure that the necessary parts and materials, meeting established quality or design requirements, are made available and are suitable for use when needed throughout the lifetime of the plant.

Spare parts and materials important to safety must be accompanied by documentation indicating that all requirements specified in the purchase order have been met.

**Outage management**

Outage management organization and administration must ensure the safe and effective implementation and control of maintenance activities during planned and forced outages. Outage planning and performance must take into consideration safety, quality and schedule in this order.

Outage planning is a continuing process involving past, next scheduled and future outages. Milestones are determined and used to track pre-outage work. Planning must be completed as far in advance as possible since circumstances may cause the outage to begin earlier than intended.

The tasks, authorities and responsibilities of different organizational
units and persons must be clearly understood. This is especially important during outage periods, when the organization may be temporarily modified. Nuclear safety during shutdown must be given careful consideration.

ALARA and waste reduction principles must be embedded in programmes and planning.

**IAEA safety standards and additional information**

1. IAEA, Safety Series No. 110, The Safety of Nuclear Installations;
2. IAEA, Safety Requirements SSR-2/1, Safety of Nuclear Power Plants: Design;
3. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
4. IAEA, Safety Guide NS-G-2.3, Modifications to Nuclear Power Plants;
6. IAEA, Safety Guide NS-G-2.6, Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants;
7. IAEA, Safety Guide NS-G-2.8, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants;
8. IAEA, Safety Series No. 50-C/SG-Q, Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations (Code and Safety Guides Q1 - Q14);
9. IAEA, INSAG Series No. 13, Management of Operational Safety in Nuclear Power Plants;
10. IAEA, INSAG Series No. 18, Managing Change in the Nuclear Industry: The Effects on Safety;
11. IAEA, Safety Report Series No. 11, Developing Safety Culture in Nuclear Activities.

### 3.5 Technical support

Technical support (TS) covers all on-site activities of the technical and engineering groups involved in surveillance testing, plant performance monitoring, plant modifications, reactor engineering, fuel handling, and application of plant process computers. The integration of technical support with its specialist functions into the plant organization is important in order to support and ensure the safe operation of the nuclear power plant.

**Organization and functions**

The goals and objectives of TS must be written and defined within the framework of plant policies and goals and be well understood by all personnel. It must be clear to staff that nuclear safety has an overriding priority. Performance indicators must be established that encourage these expectations and standards and are reported in periodic assessments.
The organization and administration of technical support ensures effective implementation and control of technical support activities. Effective implementation of the various technical support functions can be accomplished by having a separate section that is responsible for all such activities, or by having various in-plant and off-site sections providing different types of support. Either method is implemented by well-defined organization and written assignment of responsibilities, but it must be clear that overall responsibility for safety remains with the management of the plant. The interface between TS and other plant on-site and off-site groups must be clearly specified. Good coordination between the TS, Operations and Maintenance groups is of utmost importance.

The responsibilities and authorities of the technical support personnel must be clearly defined and understood by all affected personnel. The organization, qualifications and number of technical support personnel must be sufficient to accomplish the tasks assigned in the technical support area. A system is implemented to ensure that any person carrying out safety-related work is suitably experienced and qualified for that function.

Design changes are made with a full understanding of all the design information for the plant and the specifications for each system and component. Both deterministic and probabilistic assessment approaches must be used to justify and evaluate the impact of changes in the major plant design and/or operational practices. The assessment process must be sound and based on safety analyses of high quality and adequate scope. Periodic safety reviews are performed on a regular basis. The necessary knowledge of the overall plant design is retained in a form that is practically and easily available to the operating organization over the full operating lifetime of the plant. This may be achieved by setting up a 'design authority', meaning a design capability within the operating organization, or by having a formal external relationship with the original design organizations or their successors.

Plant management must be clearly committed to nuclear safety while providing technical support services. Integration of a knowledge of human factors into the routine day-to-day safety work may provide a fruitful means of improving safety performance. Such knowledge, for example, can be integrated into the planning and implementation of a major plant modification or in the investigation of an incident. Leadership and coaching can contribute to the improvement of safety performance. Line management must be accountable for the training and qualification of their personnel.

**Surveillance programme**

A comprehensive and adequately documented surveillance programme must be established and implemented to confirm that the
provisions for safe operation which were made in the design and checked during construction and commissioning continue to be used during the life of the plant. At the same time, the programme confirms that safety margins are adequate and provides a high tolerance for anticipated operational occurrences, errors and malfunctions.

The surveillance test programme must verify that the plant systems and components relevant to safety are continuously in a state of readiness to operate and are able to perform their safety functions as designed. Such a surveillance test programme must also detect ageing trends to prevent potential long term degradation.

In addition the surveillance programme can detect and correct any anomalous conditions before they significantly affect safety. The anomalous conditions which are of concern to the surveillance programme include not only failures or deficiencies but also trends, the analysis of which may indicate that the plant is deviating from the design intent.

The surveillance programme must be clearly documented and cross-referenced to the operating limits and conditions and to the safety analyses. The surveillance procedures specify surveillance requirements and identify acceptance criteria, the persons responsible for performance of surveillance activities and the periodicity of each surveillance activity.

The surveillance programme must be modified if necessary in accordance with the evaluation of the data generated during surveillance and re-evaluation of the safety analysis report. The established frequency and extent of surveillance must be periodically re-evaluated to establish that they are effective in maintaining the systems, structures and components in an operational state.

**Plant modification programme**

The overall plant modification programme encompasses all intended changes of:

- structures,
- systems,
- components and process software of the power plant,
- operational limits and conditions,
- instructions and procedures.

The design authority, or the responsible designer in his assigned area, must review, verify and approve (or reject) design changes to the plant. Design changes include field changes, modifications and the acceptance of non-conforming items for repair or use without modification.

A plant modification programme for permanent and temporary modifications is established to ensure the proper design, review,
control, implementation and documentation of plant design changes in a timely manner. All changes requested are reviewed, controlled, installed, tested and documented according to plant safety rules and procedures. The plant safety level after a modification must be within the design basis for the plant.

This programme ensures that the safety significance of a modification is adequately assessed before implementation and that its impact on reliability and design configuration is also considered.

The plant modification programme is integrated into the overall plant configuration management system that identifies documented design requirements, ensures the design is properly implemented, and controls plant changes throughout the life of the plant.

**Reactor core management (reactor engineering)**

Reactor core management ensures the safe and optimum operation of the reactor core without compromising any OLCs based on design, safety or nuclear fuel limits. Maximum effort and priority is assigned to maintaining fuel integrity. The core management programme must also provide tools to control and ensure that only approved fuel is loaded into the core.

The core management programme includes appropriate numerical methods and techniques to predict reactor behaviour during operation so as to ensure that the reactor is operated within the OLCs. The core parameters must be monitored, trended and evaluated in order to detect abnormal behaviour and to ensure that actual core performance is consistent with core design requirements. To ensure that fuel cladding integrity is maintained under all core operating conditions, radiochemical data that are indicative of fuel cladding integrity must be systematically monitored and analysed for trends. An adequate fuel failure contingency plan or policy is established and implemented to ensure that corrective actions for failed fuel are taken.

The core management programme also includes surveillance activities for the early detection of any deterioration that could result in an unsafe condition in the reactor core. The personnel involved in core management must be well qualified, have clear responsibilities and authorities, and be readily available to support plant operations during all modes of operation.

**Handling of fuel and core components**

The handling programme for fuel and other core components must specify measures to prevent damage to the nuclear fuel and to prevent inadvertent criticality and loss of appropriate cooling when fuel assemblies are being transported, stored or manipulated. For purposes of radiological protection, precautions to be taken in handling unloaded fuel, core components and materials and any disassembly operations must be specified in the procedures. The handling
programme also ensures that all procedures and controls adequately reflect radiation protection requirements and plant policies in line with ALARA principle.

The comprehensive fuel handling programme must include receipt, transfer, inspection and storage of nuclear fuel. Fuel handling planning is designed to accomplish fuel loading and unloading safely in accordance with the core management programme, as well as the safe storage, handling and preparation for dispatch of the irradiated fuel. Fuel elements are traced by means of an appropriate system to maintain a thorough fuel inventory and history. Each core component is adequately identified and a record is kept of its core location, orientation within the core, out of core storage position and other pertinent information so that an irradiation history of the component is available.

**Computer-based systems important to safety**

A programme for utilization of computer-based systems is established and implemented to support and verify the safe operation of the plant. Utilization of computer-based systems may vary greatly between different plants. The programme for utilization should therefore clearly define the categorization of the applications in terms of their safety significance. This section of the guidelines refers (if not stated specifically) to both safety systems and safety-related systems.

Organizational responsibilities for computer-based applications must be well defined and meet the needs for ensuring safe plant operation. This includes well organized documentation and provisions for emergency recovery of failed software applications.

To ensure the appropriate operation of different computer-based systems according to their design functions, a relevant section is established in the quality assurance programme.

**IAEA safety standards and additional information**

1. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
2. IAEA, Safety Guide NS-G-1.1, Software for Computer Based Systems Important to Safety in Nuclear Power Plants;
4. IAEA, Safety Guide NS-G-2.3, Modifications to Nuclear Power Plants;
7. IAEA, Safety Guide NS-G-2.6, Maintenance, Surveillance and In-Service Inspection in Nuclear Power Plants;
3.6 Operational experience (OE) feedback

A well-implemented operational experience (OE) programme is characterized by the following features:

- Management ensures the organization effectively implements the OE programme in order that plant safety and reliability are improved.
- OE is reported in a timely manner to reduce the potential for recurring events in-house and in the industry.
- Sources of OE are considered in the OE programme to improve plant safety and reliability from the lessons learned.
- OE information is appropriately screened to select and prioritize those items requiring further investigation.
- Analysis is performed of appropriate events, depending on their severity or frequency, to ensure root causes and corrective actions are identified.
- Corrective actions are defined, prioritized, scheduled and followed up to ensure their effective implementation and the effective improvement of plant safety and reliability.
- OE information is used throughout the plant to effectively improve plant safety and reliability.
- OE information is analysed and trended, and the results are used to improve plant safety and reliability.
- Assessments and indicators are effectively used to review and monitor plant performance and the effectiveness of the OE programme.
Management, organization and functions of the OE programme

A programme of OE must be in place, covering all areas of the OE feedback process. Effective use of OE is part of the safety culture. Management is committed to and involved in promoting and reinforcing the use of OE to improve plant safety and reliability. Policy, goals, objectives and management expectations are clearly defined and communicated. The programme develops procedures for the management of internal OE, including low level events and near misses, external OE, periodical assessment of OE activities and programme review.

The duties, responsibilities, authorities and lines of communication within the plant organisation are clearly defined and understood. The duties, responsibilities, authorities, lines of communication and interfaces of corporate organisations, as well as other external organisations in the OE process are clearly defined and understood. Tools such as methods, criteria etc. are provided to perform the tasks of the OE feedback process. Adequate resources are allocated for the OE programme including coordination. A group is identified to manage the process.

Active participation in OE activities is implemented throughout the plant in a blame-free atmosphere. Supervisors and managers actively reinforce the effective use of OE information by personnel.

Personnel are held accountable for effective analysis and timely implementation of lessons learned from OE information. Comprehensive monitoring of the tasks carried out in the OE process is performed for compliance with the targets defined.

The effectiveness of the OE process is monitored regularly. A clear feedback process exists in which the results of the monitoring are transmitted to the respective groups affected by the results.

Reporting of operating experience

OE is identified and reported in a timely manner according to well established criteria and procedures. Problem identification and reporting is strongly encouraged and reinforced at all levels in the organization.

Significant events, minor events, low level events, near misses and potential problems are identified and reported, including equipment failures, human performance problems, procedural deficiencies and documentation inconsistencies.

Dissemination of OE to plant personnel and dissemination of significant experience to other nuclear power plants is performed in a timely manner.
Sources of operating experience

Sources of information from the nuclear industry are identified, access to these sources are formally established and systematically screened. These sources include organizations (IAEA, NEA, WANO, INPO, National Regulatory Body, Owners Groups, Vendors and Manufacturers, Engineering designer etc.) and publications (IRS, SER, SOER; National Regulatory Body Generic Letters, Bulletins, Notices; Vendors, Manufacturers and Engineering designer problem information; Utilities and Industry event reports). Sources of OE include good practices as a source of improvement.

Sources of in-house OE are identified, information from and access to these sources are formally established and systematically screened. These sources include areas such as:

- Significant events.
- Low level events and near misses.
- Quality reports, reports and data from operation activities.
- Maintenance testing and in-service inspection.
- Surveillance reports.
- Results from plant-specific safety assessments.
- Training feedback.
- No-blame reporting programme.
- Performance indicators.

Screening of operating experience information

OE information is appropriately screened to select and prioritize the information for further investigation. Screening criteria for in-house use and industry OE are clearly established, and the criteria for the subsequent level of investigation and distribution are defined.

Screening is performed in a systematic and timely manner. The sources for screening and their corresponding frequency of screening are defined. Screening is performed by individuals with a broad knowledge of plant operations or by a multidisciplinary group.

Analysis

Analysis is performed on the events selected in accordance to their level of safety significance, severity and frequency to ensure that root causes and corrective actions are identified. Criteria for performing a full root cause analysis, a simplified analysis, and a trending analysis are clearly defined in the OE programme, and procedures for implementing them are developed.

For significant in-house events, including scrams, plant transients and important human performance and equipment problems, a rigorous investigation with full root cause analysis is performed, including causal factors, generic implications, and discrepancies between expected and actual plant responses and/or personnel actions.

For low-level events and near misses, minor events, non-consequential
events or any other useful error-related information and potential problems, the level of analysis required is clearly defined such that the generic implications, precursors of declining performance and root causes of adverse trends can be identified. Determination of corrective actions allows latent weaknesses to be corrected and to prevent their recurrence.

Personnel who have appropriate knowledge, experience and skills perform such investigations/analysis. Event participants are involved in developing and implementing corrective actions, as necessary.

Investigation of events is initiated promptly to preserve information and physical evidence and to interview participants while the events are fresh in their memories. Investigations are carried out in a timely manner.

Investigation/analysis takes account of previous similar events and precursors from both internal and external sources. Investigation/analysis is subject to objective review to ensure that root causes have been identified, which are then addressed by effective corrective actions.

**Corrective actions**

The results of OE reviews and analysis are used to identify corrective actions. Corrective actions address the fundamental causes of problems, rather than the symptoms in order to avoid the recurrence of events.

Corrective actions are prioritised, scheduled for implementation, and effectively implemented. Dates for actions are commensurate with the importance of the item, plant priorities, and the consideration of preventing recurrence. Operating shift crews are promptly briefed on events and compensatory measures are taken to prevent their recurrence.

Corrective actions are tracked for completion to verify their final implementation. A review of the status of corrective actions status and their effectiveness is periodically made. Management receives feedback on the review results.

**Use of operating experience**

OE information is used throughout the plant. Personnel are aware of management expectations in the use the OE information.

OE information is easily accessible to station personnel. Personnel are aware and knowledgeable on how to access it.

Use of OE in personnel work activities (i.e. pre-job briefings and pre-evolution briefings, work planning, shift briefings etc.) is carried out to remind the personnel involved of lessons learned and
precautions from OE, to enhance personnel alertness and to reduce risks.

OE information is used in training. It is compiled in training modules for simulator training of operators and in training of plant personnel in other areas.

**Database and trending of operating experience**

Databases related to events, deficiencies, anomalies and, deviations are established to facilitate an integral view and analysis of OE from the point of view of organizational aspects, human factors, equipment failures, work management and maintenance deviation reports. For significant events, low level events (minor events), and near misses (non-consequential events, potential problems) database trending system representations (trending parameters) are established. These then provide transparent data presentation in order to facilitate diagnosis of monitored performance, identify patterns, abnormal trends, recurrences, and promote a quick plant management overview and action focus. Trend analysis is carried out on a regular basis and the results of the analysis are reported to management. Actions are taken to correct identified adverse trends with a potential for undesirable consequences.

**Assessments and indicators of operating experience**

Self-assessments and independent evaluation are periodically performed to determine the effectiveness of the OE programme and the effective use of OE information. A self-assessment is carried out to evaluate all steps of the OE process. Management receives feedback on the self-assessment results. The results of the self-assessment are used to identify weaknesses in the OE programme and to make the improvements needed.

Indicators are used to monitor the safety performance of the plant. The trends of indicators are evaluated during self-assessment. Examples of these indicators are recurrent safety systems unavailability, industrial safety events, reactor scrams, the volume of low-level waste and radiation doses.

Indicators are used to track the effectiveness of the OE programme. Examples of these indicators are the average time for initial screening of OE documents, the number and age of reports awaiting evaluation, the number and age of corrective actions awaiting implementation, recurrent events and root causes, reworks, and the ratio of events detected through surveillance and quality programmes versus operational failures or degradation in service.

Benchmarking with industry indicators is performed and the results of the comparison are considered to determine opportunities for improvement.
IAEA safety standards and additional information

1. IAEA, Safety Series No. 110, The Safety of Nuclear Installations;
2. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
4. IAEA, 75-INSAG-4, Safety Culture;
5. IAEA, INSAG Series No. 12, Basic Safety Principles for Nuclear Power Plants;
6. IAEA, INSAG Series No. 13, Management of Operational Safety in Nuclear Power Plants;
7. IAEA, Services Series No. 10, Guidelines for Peer Review and for Plant Self-Assessment of Operational Experience Feedback Process (PROSPER Guidelines);
8. IAEA-TECDOC-943, Organizational Factors Influencing Human Performance in Nuclear Power Plants;
10. IAEA-TECDOC-1141, Operational Safety Performance Indicators for Nuclear Power Plants;

3.7 Radiation protection

The radiation protection (RP) regime established and implemented by the operating organization at a nuclear power plant ensures that in all operational states doses due to exposure to ionizing radiation in the plant or due to any planned releases of radioactive material from the plant are kept below prescribed limits and in accordance with the ALARA principle. Controls for RP during operation of the plant, including the management of radioactive effluents and waste arising in the plant, are directed not only to protecting workers and members of the public from radiation exposure, but also to preventing or reducing potential exposures and mitigating their potential consequences.

Organization and functions

The RP goals and objectives are clearly defined in the safety policies of the operating organization and communicated to the personnel and the management of the power plant. To achieve these goals and objectives a well-structured RP programme is established and implemented. The programme is documented in the plant policies and procedures and must meet the requirements set out in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS). The management ensures that the RP policies and procedures are well understood by the plant's personnel. The RP programme is clearly oriented to the achievement
of a level of performance in RP that is well above the minimum regulatory requirements.

Effective implementation of the RP programme is supported by establishing written procedures requiring high performance in RP, periodic monitoring and assessment of performance, and holding personnel accountable for their performance. Performance indicators are established that promote management expectations and standards and are reported in periodic assessments.

The RP function in the operating organization has sufficient independence and resources to enforce and give advice on RP regulations, standards and procedures, and safe working practices. Sufficient staff, equipment and funding is provided to successfully implement the RP programme. An independent RP group (in some countries known as the Health Physics Group) is established, which has the authority to enforce RP regulations, standards, procedures, safe working practices and appropriate health physics surveillance. The RP manager at the plant must have direct access to the plant's manager on all matters relating to radiation protection. The RP organization is well defined and understood, including the interfaces with other plant groups.

All levels of management and workers are committed to RP requirements and safe working practices within their level of responsibility. The RP group as well as the workers and management are trained and qualified in RP issues to a level appropriate with their responsibilities. All personnel of the plant must be aware of radiological hazards and of the necessary protective measures.

The RP programme provides 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 operating organization verifies, by means of surveillance, inspections and audits, that the RP programme is being correctly implemented and that its objectives are being met, and undertake corrective actions if necessary. The programme is reviewed and updated in the light of experience.

The principal objective of incorporating QA principles into RP is to improve safety by establishing confidence in the results of RP. Additional benefits are the strengthening of efficiency and effectiveness by establishing a system for improving RP based on the following:

- Use of relevant experience (lessons learned).
- The identification and prompt correction of deficiencies.
- The monitoring of performance.
**Radiation work control**

Exposure from sources of external and internal radiation at a nuclear power plant is reduced to such dose levels that are as low as reasonably achievable (ALARA). This principle applies both to individual and to collective doses. The responsibility for minimizing occupational exposure rests both with management at different levels and with the RP group. Work in controlled areas is authorized in accordance with appropriate procedures. Control of access and exit from radiological areas is established and maintained. A programme for monitoring radiological conditions is established for designated areas.

**Control of occupational exposure**

Occupational exposure at the power plant is controlled so that the dose limits recommended by ICRP and IAEA are not exceeded. The optimization of protection and safety measures, and the application of the ALARA principle (to keep doses as low as reasonably achievable, economic and social factors being taken into account), must be carried out. In examining working procedures and activities, the reduction of doses must be given the highest priority. A hierarchy of control measures is taken into account in optimization. Firstly, removal or reduction in intensity of the source of radiation must be considered. Only after this has been done should the uses of engineering means to reduce doses be considered. The use of systems of work are then considered and, lastly, the use of personal protective equipment.

Dose monitoring of individuals and management of dose records complies with the requirements established by the regulatory authority and are consistent with the applicable recommendations of ICRP and IAEA. Exposures related to working in controlled areas are individually monitored and recorded in order to ensure that the ALARA principle is met and that regulatory limits are not exceeded. In situations where significant concentrations of airborne activity are anticipated, appropriate internal dosimetry is available, including whole body counters. Provisions for indirect monitoring as an additional method for evaluating internal exposure are made.

**Radiation protection instrumentation, protective clothing and facilities**

Adequate radiological instrumentation, protective clothing, facilities and equipment both for normal and emergency situations are provided as part of the RP programme. The equipment and devices used to obtain radiological measurements and doses are calibrated, maintained and used so that the results are accurate.

An adequate quantity of protective equipment and clothing must be available.

**Radioactive waste management and discharges**

The generation of radioactive waste is kept to the minimum
practicable in terms of both activity and volume, by appropriate operating practices. The operating organization establishes and implements a programme to safely manage radioactive waste and to monitor and control discharges of radioactive effluents. The operating organization performs 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. Any authorized discharge limits are included in the OLCs. Radioactive waste and effluent releases are documented as required and an environmental monitoring programme is in place.

**Radiation protection support during emergencies**

The programme for RP support during emergencies is comprehensive and serves the purpose of minimizing both worker exposure and the exposure of the general public to the extent consistent with emergency conditions.

Procedures and qualified personnel are in place to provide technical and operational support during emergency interventions. Periodic training and practical exercises must be undertaken to ensure an effective response in the event of an emergency.

**IAEA safety standards and additional information**

1. IAEA, Safety Series No. 111-F, Principles of Radioactive Waste Management Safety Fundamentals;
2. IAEA, Safety Series No.115, International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources;
3. IAEA, Safety Series No.120, Radiation Protection and the Safety of Radiation Sources;
4. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
7. IAEA, Safety Guide RS-G-1.1, Occupational Radiation Protection;
8. IAEA, Safety Guide RS-G-1.2, Assessment of Occupational Exposure Due to Intakes of Radionuclides;
9. IAEA, Safety Guide RS-G-1.3, Assessment of Occupational Exposure Due to External Sources of Radiation;
10. IAEA, Safety Guide RS-G-1.4, Building Competence in Radiation Protection and the Safe Use of Radiation Sources;
11. IAEA, Safety Report Series No. 21, Optimization of Radiation Protection in the Control of Occupational Exposure;
3.8 Chemistry

Chemistry refers to activities involving chemical treatment to maintain the integrity of the barriers retaining radioactivity, including the fuel cladding and primary circuit. The chemistry activities have a direct impact in limiting all kinds of corrosion processes causing either a direct breach of safety barriers or their weakening so that failure could occur during a transient.

In addition chemical treatment includes consideration of its effects on the out-of-core radiation fields that in turn influence the radiation doses to which workers are exposed. Plant radiochemistry is included in the chemistry area for the purpose of these guidelines.

**Organization and functions**

The operating organization establishes a chemistry policy for its nuclear power plants. The policy states the goals and objectives of the chemistry programme and the expectations of the management concerning the implementation of this programme at the plant(s). Performance indicators are established that encourage these expectations and are reported in periodic assessments.

A specific chemistry group is established at the plant to implement the chemistry control programme. The organization of the chemistry group contributes to safe operation, defines responsibilities and establishes lines of communication inside and outside the group. The position of this group in the organization reflects its relevance. The interfaces between the chemistry group and other groups are clearly specified especially as regards allocation of authorities. The chemistry group is consulted when issues affecting chemistry are being addressed. The qualifications and number of chemistry personnel must be sufficient for their assigned responsibilities and to support all plant operations.

The chemistry group's expectations, goals and objectives are derived from the plant policies and objectives, and defined in line with design recommendations, and international good practice. They must be well understood by the chemistry personnel.

The monitoring of the chemistry group's performance and its programmes includes self-assessment of managerial processes and work performance.

**Chemistry control in plant systems**

The plant must have an established and implemented comprehensive chemistry control programme. This programme is implemented by clear procedures and monitored by adequate performance indicators. The plant staff concerned have a good understanding of the programme, procedures and indicators.
Chemical treatment processes take into account the plant material concept and any change in plant material concept is evaluated by the chemistry group.

The generation and transport of radioactive products within the primary system must be understood, controlled and minimized.

Some results of the chemical analyses are issued through computer software. This software should be reviewed in a timely manner.

Chemical treatments are optimized with respect to environmental and radwaste aspects. The basis of such optimization along with procedures to support the implementation of this concept must be documented in a written form.

**Chemistry surveillance programme**

The chemistry surveillance programme includes the monitoring, sampling and trending of chemical and radiochemical parameters at specified frequencies to ensure the timely detection and correction of abnormal or unacceptable trends and conditions. The chemistry surveillance programme reflects chemistry specifications for all phases of plant operation, including shutdown periods and when systems are taken out of operation for prolonged periods.

Procedures for analysis and measurement are available and well understood by the personnel of the chemistry group. Personnel performing analyses are technically qualified and their performance periodically assessed. Analytical techniques are appropriate, safe and the evaluated results are transmitted in a timely manner to the appropriate operational personnel. The chemistry data is constantly evaluated to identify any chemistry control problems and analytical errors and to remove deficiencies.

The responsibilities for QA are defined and the QA programme is implemented and evaluated in accordance with the QA programme.

**Chemistry operational history**

The results of analyses and investigations must be adequately trended, evaluated and reported. Records are available and easily retrievable. Lessons and experiences from previous events and history, including those from other plants, are considered in the plant chemistry programme.

**Laboratories, equipment and instruments**

The laboratories have adequate space, supplies and equipment. The sampling systems are reliable and safe for use, including post-accident sampling systems. Necessary and adequate instruments for performing analyses are available and calibrated.
**Quality control of operational chemicals and other substances**

The purity and authenticity of chemicals and other substances which might have an impact on safety-related systems are specified and controlled. Before being used the specified values are verified either through certification or by chemical analysis.

**IAEA safety standards and additional information**

1. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
2. IAEA, Safety Guide NS-G-2.2, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants;
5. IAEA, Safety Series No. 50-C/SG-Q, Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations (Code and Safety Guides Q1 - Q14);
3.9 Emergency planning and preparedness

Emergency preparedness is the capability to take actions that will effectively mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment. This section refers to emergency planning and preparedness of a nuclear plant both on-site (operator responsibility) and off-site (mostly the responsibility of local and state authorities).

The practical goals of the emergency response in a nuclear or radiological emergency are:

- To regain control of the situation;
- To prevent or mitigate consequences at the site;
- To prevent the occurrence of deterministic health effects in workers and the public;
- To render first aid and manage the treatment of radiation injuries;
- To prevent, to the extent practicable, the occurrence of stochastic health effects in the population;
- To prevent, to the extent practicable, the occurrence of adverse non-radiological effects on individuals and among the population;
- To protect, to the extent practicable, the environment and property;
- To prepare, to the extent practicable, for the resumption of normal social and economic activity.

The goals of the emergency response are most likely to be achieved by having a sound programme for emergency preparedness in place as part of the infrastructure for protection and safety. The practical goal of emergency preparedness is to ensure that arrangements are in place for a timely, managed, controlled, coordinated and effective response on-site and off-site (at the local, regional, national and international level), to an emergency.

For that purpose, an emergency preparedness programme is necessary that includes national, local, and on-site response organizations. In a consolidated approach, the elements to be evaluated may be addressed by the operator, the local authorities or the national authorities, or by a combination thereof, so long as the arrangements are well coordinated. Weaknesses at one level could be compensated at another.

Emergency programme

Arrangements including clearly assigned authorities and responsibilities, organization, coordination, personnel, plans, procedures, facilities, equipment and training must be in place to provide reasonable assurance of an effective response in the case of any nuclear or radiological emergency at the site.
An effective administrative framework is available for the planning, implementation, co-ordination and control of emergency preparedness activities. This framework is well documented, defining responsibilities and authorities and appropriately considers the requirements of the regulatory authority.

The policy of the operating organisation ensures that all emergency preparedness activities at the plant are properly organized and are integrated with those of the operating organisation's headquarters organization, the relevant emergency services, the local and national authorities, with due consideration of interface implications. Authorities and responsibilities are well established and clear among all the organizations involved.

The operating organization ensures that adequate human and financial resources are allocated, that critical response functions are covered and that the state of preparedness is properly maintained, regularly tested and updated. All emergency planning and preparedness activities are properly covered by the QA programme.

A close and co-operative relationship is maintained between the on-and off-site response organizations.

The response organizations periodically conduct a review in order to ensure that all events (including those of very low probability) that could necessitate an emergency response are addressed by the emergency arrangements. This includes a review and appropriate revision of the emergency arrangements before any changes to existing operations or new operations are undertaken on site or nearby that might result in events warranting an emergency response.

**Response functions**

The emergency preparedness arrangements in place provide reasonable assurance that the response functions discussed in this section can be performed effectively during an emergency.

**Emergency plans and organization**

Approved emergency plans clearly allocate responsibilities and provide a basis for development of procedures, training and other arrangements that provide for a coordinated response by the operating organization and other authorities.

The emergency plans include arrangements for emergencies involving a combination of non-nuclear and nuclear hazards, and the response of conventional response organizations such as law enforcement. These plans are reviewed regularly taking into consideration the feedback from drills and exercises, and considering any revisions to facility operations, the terrorist threat situation, or activities/conditions in the area that may impact on the potential emergencies to be addressed or the response to them.
**Emergency procedures**

Procedures and analytical tools are available, validated and provide detailed guidance for the rapid and effective implementation of the response functions. On-site procedures are linked with the plant documentation and records management system.

**Emergency response facilities**

Facilities are provided for adequate on-site and off-site emergency responses with appropriate communications and equipment that can be brought into operation without delay in the event of an emergency. These include centres from which the on-site and off-site emergency responses can be managed, as well as means for assessment of plant status and radiological conditions, and for implementation of any necessary response actions or protective measures. In addition, special facilities for the protection of personnel and the public, such as e.g. assembly points and medical centres are available.

**Emergency equipment and resources**

Adequate emergency equipment and resources, communication systems, documentation (such as procedures, checklists, telephone numbers and manuals) are available where needed to properly initiate and support the emergency response actions. The necessary data transfer and communication is also available.

Instruments, tools, equipment, documentation and communication systems to be used in emergencies are appropriate and are maintained in good operating condition, in such a manner that they are unlikely to be made unavailable by the postulated emergency and environmental conditions. Equipment, communications, vehicles etc. are regularly checked and tested.

**Training, drills and exercises**

A comprehensive, documented training programme is provided for developing and maintaining the necessary knowledge, skills and physical ability required for all persons having duties under the emergency plans to enable them to respond correctly and efficiently in the event of an emergency. A programme is also provided for general employee training of on-site personnel. Similar training, or at a minimum, a well-structured information briefing, is provided to plant visitors.

A programme of periodic drills and exercises is set up to reinforce the training and assess the effectiveness of the emergency response capability. The programme includes periodic, comprehensive and integrated on-site and off-site exercises aimed at assessing the coordinated response of all emergency response organizations, as well as evaluation of these exercises for experience feedback.

**Quality assurance**

A quality assurance and maintenance programme is in place that
ensures a high degree of availability and reliability of all plans, procedures, supplies, equipment, communication systems and facilities necessary to perform specified functions in an emergency.

**IAEA safety standards and additional information**

1. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
2. IAEA, Safety Guide NS-G-2.2, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants;
3. IAEA, Safety Guide NS-G-2.8, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants;
4. IAEA, Safety Series No. 50-C/SG-Q, Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations (Code and Safety Guides Q1 - Q14);
5. IAEA, Safety Requirements GS-R-2, Preparedness and Response for a Nuclear or Radiological Emergency;
6. IAEA, INSAG Series No. 10, Defence in Depth in Nuclear Safety;
7. IAEA, INSAG Series No. 12, Basic Safety Principles for Nuclear Power Plants;
8. IAEA-TECDOC-955, Generic Assessment Procedures for Determining Protective Actions during a Reactor Accident;
9. IAEA, (updating IAEA-TECDOC-953) EPR-METHOD, Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency;

### 3.10 Commissioning

Commissioning is the process during which plant components, systems and structures, after construction, are tested and placed in operation with the objective of verifying that they are in accordance with the design assumptions. This process continues until the plant is at full power and the required testing at this power level has been conducted. In order to meet the expected performance criteria the plant is verified 'as built' and pre-operational plant adjustments are made. Commissioning also includes testing prior and subsequent to fuel loading. It is therefore essential to safety that the commissioning programme and individual system testing be designed in such a way that the design assumptions can be verified and quality can be assured throughout the commissioning process.

**Commissioning is the process of fine-tuning and testing the power plant before operation.**

The commissioning process is the best method to prepare personnel
and procedures for the normal operation of the plant. Operating personnel in all disciplines are involved as much as possible in commissioning activities and the operating procedures are validated to the extent practicable with the participation of future operating staff.

During commissioning an extensive amount of data is collected on structures, systems and equipment. This 'base line' data forms the reference for subsequent operational testing in order to prevent plant degradation.

The commissioning programme and results are an important part of the licensing process of the plant. Clear and well defined responsibilities and requirements for the operating, commissioning and regulatory organizations are essential to satisfy the licensing requirements for the plant in a timely manner.

The commissioning results greatly depend on the interfaces among construction, operations and designers. The boundaries of responsibility vary from site to site. The levels of cooperation between these groups influence the quality of commissioning.

The responsibility for the plant is eventually transferred to the operating organization. This could be done gradually or in specified stages. Quality and comprehensiveness in this handover is necessary to ensure an adequate history and that the plant meets the design intent.

**Organization and functions**

Responsibility for commissioning may rest with a contractor, the construction organization or the operating organization. Nevertheless, since the time of fuel load the responsibility for nuclear safety must rest with the licence holder, usually the operating organization. Whatever the arrangement, it is important that the organization or individual responsible for commissioning be accountable to the organization or to the individual responsible for compliance with the licence to demonstrate that the plant behaves in accordance with the design assumptions, and to confirm that the plant is only tested in a fashion for which the design is satisfied.

The commissioning organization must adequately meet the standards of quality established within the plant organization. The functions and responsibilities for the commissioning process are clearly defined with well-developed lines of authority for all persons involved.

Good coordination between the commissioning organization and the operating organization at all levels is evident. Clear lines of responsibility and authority for contractor organizations are developed and understood by all those involved in commissioning.

A sufficient number of qualified personnel must be available during
all stages of commissioning. Operating personnel and plant technical staff are involved in the commissioning process to the extent necessary for ensuring proper preparation of the operational phase.

The responsibility of the regulatory authority in the commissioning programme is clearly defined and well understood by the commissioning organization and the operating organization.

**Commissioning programme**

The commissioning programme is a management tool which allows those responsible to satisfy themselves that the scope and sequence of the commissioning process is fit for purpose and against which it may be controlled. It also provides a reference against which the regulator may monitor and approve the process, and for allocation of safety responsibilities at different stages during the commissioning process from fuel arrival at the plant to full power operation.

A good commissioning programme is structured to ensure that the following objectives are met:

- All the tests necessary to demonstrate that the installed plant satisfies the design intent are conducted.
- The tests are performed in a logical sequence.
- The programme provides a means of identifying hold points in the commissioning process.
- Operations personnel are trained and procedures validated.

Commissioning activities are scheduled to align them with critical path activities and take into consideration all the organizations involved. The schedule ensures that tests are performed in a logical sequence.

A good commissioning programme is continuously improved. This cannot be achieved without a good incident reporting and analysis system. The information obtained from this analysis is not only fundamental for the commissioning programme, but also for subsequent operations of the plant.

**Training in commissioning**

The commissioning of a NPP is a relatively quick transition from construction to operation. Throughout this process, significant changes in methods and disciplines occur. For this reason training and assessment of the commissioning personnel must be well established, understood and conducted in a timely manner in order to meet the quality requirements of the commissioning programme at any time.

The training group must be well staffed with experienced personnel in all subjects and the training programme contains specific commissioning aspects. Designers, vendors, main contractors and operations are encouraged to participate in the training programme because of the close interaction required during this phase.
Given the plurality and different backgrounds of the personnel involved in commissioning, a spirit of safety and quality is established at all levels from the early stages of commissioning. The importance of their work in attaining the quality and safety objectives expected must be highlighted in the training programme.

**Preparation and approval of test procedures**

The test procedures define in detail how each piece of equipment or system will be commissioned and thus form the core of the commissioning process. Competent personnel and adequate controls are in place to ensure high commissioning standards.

Commissioning test procedures are available in accordance with the commissioning schedule well before the test is conducted to allow sufficient review time and prevent delays in the programme.

The test procedures are consistent with the detailed guidance provided. Test controllers have a clear understanding of all instructions. Each test provides sufficient data to satisfy the design intent of the system or component being tested and to meet the requirements of the plant’s final safety analysis report.

Tests that may place the plant in an unanalysed condition must not be performed. Any changes to approved procedures are authorized in advance and controlled.

The procedures are subject to a thorough verification and approval process in which beyond commissioning, the regulatory authorities and the operating organization play an important role.

**Control of test and measuring equipment**

Test results gathered during commissioning can only be as accurate as the instruments and calibration methods used. It is important to note that test results are taken from permanently installed instrumentation as well as from special test equipment. Nevertheless, the criteria for accuracy are clearly established.

A variety of test equipment is available in advance to ensure that the appropriate test equipment is used in every test.

Since several organizations are usually involved in commissioning, calibration responsibilities are clearly assigned. A review is performed to determine that the controls in place ensure that measurements are made and instruments are used in a manner which can be traced back to a recognized standard.

**Conduct of tests and approval of test results**

The organization, personnel, controls and procedures for conducting the tests must be effective in practice. The objectives in collecting the
necessary data to demonstrate that the plant performs in accordance with the design intent, providing base line data for the plant surveillance programme and ensuring adherence to procedures and administrative documentation must be satisfactorily met. Changes to test procedures are properly authorized and controlled. A rigorous adherence to test and administrative procedures as well as to existing policies during the conduct of a test and approval of test results, as well as a questioning culture at all levels are exercised for the safe operation of the NPP. Adequate storage processes, facilities, safety and retrievability of commissioning records are ensured.

**Maintenance during commissioning**

From construction to commissioning and finally to operation the plant is adequately monitored and maintained in order to protect the equipment, support the testing phase and continue to satisfy the safety analysis report. To accomplish that, the organization in charge is well structured and staffed with sufficient and appropriately qualified staff. Furthermore, responsibilities for control and maintenance of spare parts are clearly defined and executed.

Maintenance applied during commissioning is up to the same standards applied during operations. Historical records of operations and maintenance are kept from the initial start-up and operation of each plant system, and provisions are made to eventually hand them over to operations.

The scope of responsibilities of construction and operations regarding maintenance during commissioning is clearly identified. The organization established ensures that the maintenance group of operations either participates or becomes actively involved in the commissioning maintenance organization at all levels, including validation of documentation.

**Interface with operations**

The responsibilities of the operating personnel at the plant in relation to commissioning are as follows:

- To satisfy themselves that the systems which are transferred comply with specified performance requirements, the design intent and safety requirements.
- To accept responsibility for the transferred systems.
- To participate in the commissioning activities.
- To become competent in the methods of operation of the plant.
- To carry out operation and maintenance with competent staff using approved techniques to meet the needs of the commissioning programme.

The plant executes plans to incorporate operating personnel in commissioning activities at all levels, thus providing the operating staff with an opportunity to become familiar with, and gain experience on their own plant. Operations personnel must be fully and timely
informed of commissioning activities.

Responsibilities for nuclear safety are well defined and understood from the arrival of new fuel and core load.

Operating procedures are used to the extent that the conditions of the plant allow during the commissioning phase, so as to validate them prior to the initial core load. Inter-organizational arrangements are made to schedule this activity to ensure that operating, maintenance, surveillance and chemistry procedures are adequately validated.

Personnel adhere to normal operating rules, such as access to the control room, control of I&C cabinets and switch boards, and communications with the control room for abnormalities and changes in plant configuration. This adherence is emphasized after the core is loaded.

**Interface with construction**

The responsibilities of the construction group in relation to the commissioning process include the following:

- To ensure that the installation of structures, systems and components has been completed in accordance with design requirements and specifications.
- To make suitable arrangements for surveillance and maintenance to prevent deterioration after the completion of installation and before the handover.
- To issue certificates of completion of installation giving the necessary assurances to the commissioning group.
- To provide, for use as baseline data, as-built documentation of the installation and test certificates, highlighting design changes and concessions.
- To transfer the installed systems to the commissioning group using a system of documents such as transfer certificates.
- To correct deficiencies in installation detected in commissioning.

Clear and well-understood authorization and communication lines are established and documented between the construction and commissioning groups to manage the rigorous work prioritization policy established by the commissioning group. These communications support the commissioning schedule and the agreement on the scope of activities in both organizations, in particular at the interfaces.

The responsibilities of the construction group in the testing programme are well defined in advance of commencement of this programme in order to prevent misunderstandings. This participation is properly scheduled to meet construction and commissioning requirements.
The quality of maintenance activities must follow operational QA standards during commissioning, especially from core loading where the licence holder is responsible for ensuring this. During the commissioning phase, special attention is paid to ensuring that the equipment is adequately tested after construction interventions.

**Interface with engineering (designer)**

During the commissioning process a thorough validation of the design of the plant is carried out. As a result, a comprehensive programme to identify any weaknesses in design and equipment deficiencies is established. The effective prioritization and resolution of these deficiencies must be closely associated with the quality and effectiveness of the process, documentation, and communications established between the commissioning and the design organization.

Mechanisms exist at the plant to confirm that all design changes are approved and conform to the design intent. This is achieved by thoroughly evaluating the proposed design changes prior to their implementation by all the organizations involved and by testing the system or equipment after implementation of the changes. In addition, the commissioning organization has the adequate level of authority to set priorities for evaluation and implementation of changes proposed.

All documentation affected by design changes are updated in a timely manner and relevant personnel informed. Close adherence to these rules ensures that plant configuration is maintained at all times and therefore that nuclear safety is not jeopardized during the operation of the plant.

**Initial fuel loading**

Initial fuel load is of great significance because it is the first time that the fuel is brought into a potential critical configuration. This potential for criticality carries with it the potential for radiation hazards, contamination and even nuclear emergencies. The procedure for fuel loading must limit the risk of criticality as far as practicable and ensure that measures to control all these hazards are in place before fuel load commences.

When the first fuel assembly is inserted into the reactor core, the responsibility for nuclear safety at the plant rests with the licence holder or his designee, usually the plant manager. Although responsibilities for nuclear safety commence upon arrival of the fuel to the site, responsibilities prior, during and subsequent to this hold point are well defined and understood by the construction, commissioning and operations organizations.

In order to confirm that the plant is prepared for the initial core loading, prerequisites regarding testing, systems, equipment, documentation and personnel are established well in advance. These prerequisites are clearly described and documented based on the
safety analysis report and the existing regulatory requirements. These prerequisites are satisfied well in advance of the initiation of fuel loading.

Prior to this hold point the plant personnel is qualified and trained to a sufficient level to be able to operate the plant in safe conditions.

**Plant handover**

Plant handover is the transfer of responsibilities for the plant. This transfer is comprehensive and includes systems, equipment, structures and documentation and may include personnel. According to the plant organization and within the handover framework, two separate types of transfers may be found; one from construction to operations directly and the other from construction to commissioning and finally to operations. All these responsibilities and authorities are clearly established, documented and understood.

Systems are transferred gradually to the operating organization as soon as the non-nuclear tests are performed and approved. In this way the operating organization can carry out the inspection in a thorough manner prior to acceptance. Systems are also transferred before the pre-nuclear tests are performed or approved, with exclusive operating responsibilities. Systems and equipment handover are well controlled and differentiated from ongoing commissioning activities and the operations group should be informed in a timely manner.

The transfer of documentation is a key feature in the handover process. This is done in system packages and takes place over a reasonable period of time in order for the plant personnel to be able to make a comprehensive review of every package. These transfers also depend on how the responsibilities for the post-fuel load, low power and power escalation testing are assigned.

**Work control and equipment isolation**

During commissioning of the plant there is a large amount of work that must be done in parallel with the commissioning activities. Responsibilities and authorities to carry out this work are clearly established, documented and understood by all the organizations involved.

This work is adequately managed to ensure that the testing programme is not impaired and to ensure that the equipment tested after interventions is in accordance with established safety standards. The fulfilment of these objectives is closely associated with the effectiveness of the communications, coordination and authorities established.

During construction, equipment may be worked on without any potential hazard arising from the energy (electricity, heat, pressure, etc.) contained therein. However after initial start-up, a set of rules
with appropriate training of personnel in these rules are required to ensure that workers are protected from these hazards during their work.

**Control of temporary modifications**

Inevitably, the process of commissioning requires some temporary modifications (e.g. jumpers, lifted cables, temporary blank flanges, safety valve gags, interlock defeats, nonstandard software). Since temporary modifications interfere with the design configuration, they are properly assessed and controlled.

The process of controlling temporary modifications must satisfy the following objectives:
- When the design configuration of the plant is modified the safety implications are properly considered.
- Modifications are properly documented and marked for easy identification and all groups affected are informed in time.
- The design configuration is restored following temporary modifications.

The safety of the plant strongly depends on the control and management of temporary modifications. Therefore, the responsibilities before and after core load are well defined, documented and understood and the whole process of implementation, control and removal of temporary modifications is conducted rigorously and carefully.

**IAEA safety standards and additional information**

1. IAEA, Safety Requirements SSR-2/2, Safety of Nuclear Power Plants: Commissioning and Operation;
2. IAEA, Safety Guide NS-G-2.2, Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants;
5. IAEA, Safety Series No. 50-C/SG-Q, Quality Assurance for Safety in Nuclear Power Plants and Other Nuclear Installations (Code and Safety Guides Q1 - Q14);

### 3.11 Questions

1. Why are administrative procedures, rules and instructions needed in nuclear power plant?
2. The operating organization has a general policy. State the purpose for this policy!
3. List all documents which are included in the document and
4. What is the purpose of the training and qualification programme for control room operators and shift supervisors? Describe what they are capable of doing after their training programme.

5. What elements are included in training programmes for maintenance personnel?

6. What information does a new employee in the general employee training receive?

7. List and briefly describe the operating procedures.

8. What is included in a comprehensive programme for fire prevention and protection?

9. What is the purpose of establishing an additional organizational structure in the case of an accident condition?

10. List all types of maintenance programmes.

11. How is maintenance work performed?

12. Why is it important to integrate technical support into the plant organization?

13. What is included in an overall modification programme?

14. What is the purpose of reactor core management?

15. List the features that characterize a well-implemented operating experience programme.

16. Describe the sources of operating experience.

17. Define the sequence of control measures when the optimization of occupational exposure is performed.

18. What is the purpose of chemical treatment activities?

19. List the practical goals of the emergency response.

20. What is emergency preparedness?

21. What are the objectives of a good commissioning programme?

22. What are the responsibilities of the operating personnel during commissioning?

23. What is the purpose of the plant handover?
REFERENCES


[15] INTERNATIONAL ATOMIC ENERGY AGENCY,


[34] IAEA – BPTC Module 18, Decommissioning.


[38] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Defence in Depth in Nuclear Safety, INSAG Series No. 10, IAEA, Vienna (1996).


The views expressed in this document do not necessarily reflect the views of the European Commission.