SAFETY GUIDES

ON IMPLEMENTATION OF THE LEGAL REQUIREMENTS

SAFETY GUIDE

Safe Operation of Nuclear Power Plants

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АГЕНЦИЯ ЗА ЯДРЕНО РЕГУЛИРАНЕ
BULGARIAN NUCLEAR REGULATORY AGENCY

TABLE OF CONTENTS

1. GENERAL PROVISIONS

LEGAL BACKGROUND

1.1. This Guide is issued pursuant to paragraph 6 of the transitional and final provisions of the Regulation to ensure the safety of nuclear power plants (the Regulation) [1].

1.2. A nuclear power plant may consist of one or more nuclear installations - units. According to the context, guidelines may refer to the whole plant or a separate unit.

1.3. This Guide complements the legal pyramid of NRA requirements, governing the safety of nuclear power plants – Act on the Safe Use of Nuclear Energy [2], regulations implementing the law and respective guidelines.

OBJECTIVES

1.4. The guide is intended for applicants and licensees who operate nuclear power plants.

1.5. Guide objective is to provide additional information and interpretation of regulatory requirements as specified by Chapter 5, Section IV "Operation" of the Regulation [1].

1.6. The Guide aims to assist the establishment with licensees of common or similar criteria and understanding when dealing with issues related to the safe operation of the plants.

1.7. Only the most important to the NRA safety aspects are being considered. NRA understanding is that daily practice of NPPs operation is much more complex and can not be covered by a single guide.

1.8. Some of the recommendations derive from requirements and "best practices" as described by the IAEA documents.

1.9. The Guide provides guidance on regulatory expectations in respect to licensee documents and practices during the operation of the nuclear facility.

1.10. The Guide is of a recommendatory nature. It includes advice on how the legal requirements with respect to the save operation of NPPs, as stipulated in reference documents [1] – [4], should be fulfilled.

1.11. The specific implementation of the statutory requirements should be determined by the licensees themselves, who bear the overall responsibility for safety.

SCOPE

1.12. This Guide is applicable to the operation of nuclear power plants with pressurized water reactors (WWER water-water energy reactors).

1.13. The Guide covers only part of the issues related to the direct management of safety during operation at plant or unit level. Regulatory requirements concerning operating organizations, personnel, emergency preparedness, physical protection, commissioning, etc., are not discussed herein.

1.14. The Guide includes texts that explain to a further extent some of the requirements of the Regulation [1], taking into account the IAEA recommendations and where appropriate "good practices" of other regulatory bodies as described in reference documents [5] – [19].

1.15. The Guide should not be regarded as Operating technical rules for NPPs.

1.16. The Guide includes texts that to a large extent are known by the staff. The aim is to transfer the spirit of the Regulation [1], and additionally to incorporate the feedback from NRA regulatory inspections. It is also expected that additionally this document may have an educational aspect and to contribute to a better understanding of safety culture by the operating staff.

1.17. Where necessary, certain terms are explained at the end of the document.

2. GENERAL ASPECTS OF NPP SAFETY

MANAGEMENT AND OBJECTIVES OF OPERATIONAL SAFETY

2.1. The licensee should develop and implement a policy in which the safety of nuclear installations is of highest priority. Safety policy should encourage the development of comprehensive safety culture and a critical approach to all activities important to safety. The management policy on nuclear safety should be pervaded in all documents and activities.

2.2. Management expectations on nuclear safety issues should be clearly addressed to the staff. The staff should understand this policy and should be aware of its role and responsibilities for ensuring safe operation. The safety policy should be transferred into requirements and expectations internally into the NPP as well as to external organizations providing services to the plant.

2.3. Safety policy should involve awareness of the need for periodic evaluation of plant safety, in compliance with the regulatory requirements and with respect to operating experience and significant new safety related information, including implementation of corrective measures if applicable.

2.4. Safety policy should also include understanding of the need for continuous improvement of the characteristics of operational safety, finding more effective ways of performance, as well as implementation of extensive research to achieve the requirements of modern standards. Licensee activities should be expressed by a well defined program with clear goals and objectives.

2.5. The main safety goal of the nuclear power plant should be protection of personnel, public and the environment from unacceptable radiation impact at all different stages of plant lifetime – commissioning, operation and decommissioning.

2.6. The safety goal should be achieved through the implementation of technical and radiological safety objectives.

2.7. Radiological objective is achieved by not exceeding the statutory limits for radiological impact to personnel, population and the environment during normal operation, deviations from the normal operation and design basis accidents. NPP should strive for creating adequate conditions to keep to the minimum possible radiation impact.

2.8. The technical objective is to take all possible technical and organizational measures to prevent accidents and limit their consequences.

2.9. Operating organizations should monitor and assess safety and should report to the regulatory body on all activities and outcomes.

2.10. The fundamental principle of the operating organization in respect to its technical policy is to maintain high level of safety and strive for continuous improvement, taking into account the achieved scientific and technical knowledge, research, experience and recommendations.

SAFETY CRITERIA

2.11. A nuclear power plant meets the safety requirements, if the fundamental safety objective is achieved as a result of implemented design, technical and organizational measures.

2.12. Safety criteria for existing units (core damage frequency and large early releases into the environment) are listed in § 3 (2) of the transitional and final provisions of the Regulation [1], as criteria for new units are specified in Art. 10 of the same document.

2.13. Regulatory limits for personnel and public exposure, the amount of radioactivity released into the environment and its composition (for normal operation, deviations from the normal operation and accidents) are specified by the Regulation on the Basic Norms for Radiation Protection [3]. Specific values for discharges and doses received are set out in the same places in the Regulation.

SAFETY PRINCIPLES

2.14. Principles to ensure safety can be regarded as fundamental and general - organisational and technical [4].

2.15. To the fundamental principles can be assigned:
- State regulation of safety;
- Responsibilities of operating organizations;
- Implementation of a Defence in Depth (DiD) strategy;
- Ensuring Safety Culture (SC).

2.16. To the general organizational and technical principles are assigned:
- Application of proven engineering and technical practices;
- Quality management;
- Self-assessment of NPPs safety;
- Safety Analyses and Assessments;
- The exercise of internal supervision;
- Independent verifications;
- Consideration of human factors and behaviour;
- Provision of radiation protection;
- Reporting of operating experience;
- Providing scientific and technical support.

2.17. Some of the activities, related to the implementation of the principles are described in general below.

Quality Management

2.18. Plants should develop a quality management system for all safety related activities, which expands throughout the lifetime of the plant.

2.19. All external organizations, equipment suppliers and contractors, providing services to the NPP, should develop and implement their own quality management systems for the respective services they provide. The staff of the external organizations must be aware of the consequences of failure to follow instructions, requirements and standards on nuclear safety and radiation protection.

Self-assessment of NPP Safety

2.20. To justify further safe operation of the plant, nuclear power plant should perform periodic comprehensive safety assessment using its own internal methodologies. The assessment should include comparison of the current safety level with the best practices, resulting in implementation of programs and measures to improve design and operational safety.

2.21. Assessment frequency should be determined by the NPP. However, such an assessment is obligatory when applying for renewal of the operating license. Specific requirements for implementing safety measures can be set as license conditions.

2.22. The safety assessment should be complex and systematic in nature in respect of design evaluation - functional sufficiency and reliability of systems, failures, human errors, organizational and technical measures to prevent and mitigate the consequences from deviations, incidents and accidents.

2.23. For licensing purposes, in respect of application for extension of operating lifetime of structures, specific lifetime assessments are required for SSCs.

Internal Control over the Conditions of SSCs and Processes

2.24. The NPP should establish an internal organisational unit for institutional controls over compliance with the limits and conditions for safe operation. The unit should develop and implements programs and methodologies for internal inspections with the aim of early detection of deficiencies and negative trends.

2.25. The NPP should establish an internal organisational unit for institutional oversight of SSCs and high-risk equipment and facilities (pressure vessels, cranes, primary boundary, etc.).

Independent Review

2.26. Best practices oblige the NPP to organize periodic safety peer-reviews and missions with the involvement of experts from other nuclear power plants or from international organizations. The results of these missions should be analyzed and corrective actions should be implement where appropriate.

2.27. Under the Bulgarian legislation, NPP management is obliged to render full assistance in periodic inspections to verify plant safety, carried out by the state specialized supervisory bodies.

Consideration of Human Factors

2.28. When drawing the operating and emergency procedures, the possible errors of operating and maintenance staff should be considered.

2.29. To eliminate or soften the consequences fro human errors, some of the following means and methods could be applied:

- Selection and staff training of high quality, continuous improvement of personnel qualification and skills, training to safely perform activities - short pre-job briefings, compliance with safety requirements and shift system, development of programs and check lists;
- Analysis and correction of shortcomings in staff training and performance;
- Use of diagnostic tools (control of technical conditions) of systems and components important to safety;
- Use of hardware and software to unit any wrong action by the staff;
- Continuous improvement of operational and maintenance documents - instructions, manuals, programs, methods and technical means to monitor the working conditions of safety important SSCs ;
- Implementation of institutional supervision;
- Educating and continuously improving safety culture.

3. REQUIREMENTS AND RESPONSIBILITIES FOR SAFE OPERATION OF NPPS

RESPONSIBILITY FOR SAFETY

3.1. The Guide does not cover the functions and responsibilities at the level of the operating organization or the utility.

3.2. The NPP management should have the responsibility for the overall management of the processes in the facility, not only through itself but also by delegating powers and responsibilities to managers from a lower level.

3.3. The plant Chief Engineer of power generation section has been given the responsibility for the safety of managed facilities. Respectively, he/she could delegate rights and responsibilities among the particular line managers in the different fields.

STRUCTURE AND ORGANISATION OF OPERATIONS

3.4. For the performance of assigned duties, the Chief Engineer should be assisted by a specific structure and personnel, mostly suitable for the implementation of direct goals and tasks.

3.5. The Chief Engineer approves the Rules of Procedure, which specifically define the responsibilities, duties and powers of all structural units and their staff. Substitution responsibilities, obligations and procedures should be explicitly specified in the documents. Appointed personnel should know and understand their assigned powers and responsibilities.

3.6. Administrative structures and control mechanisms should be established, which to provide supervision and verify that plant activities, at all operating states, are being planned and implemented in accordance with the principles and requirements for safe operation.

3.7. Structures that have control functions, especially in respect to operations and safety, should be provided with a certain degree of independence by their direct subordination to the Chief Engineer.

3.8. Responsibilities and duties of each individual are defined in job descriptions, developed according to the performed activities and respective position. Job descriptions should require that the individual maintains professional knowledge and skills, undergoes recurrent training, and understands and respects the principles of NPP safety.

3.9. The Chief Engineer should be assisted by Specialised Advisory Councils, which to meet periodically or when there is a need to resolve particular issues.

3.10. The effectiveness of Advisory Councils is depending on their organizational arrangements - preparation and distribution of written materials, in-depth knowledge of the matter and provision of beneficial advice. An important element is that decision making deadlines and timeframes for implementation of planned measures are realistic.

3.11. The activities of the Specialised Advisory Councils should be documented to an acceptable extent. The procedure for control and implementation of councils' decisions should be specified in and internal document, issued by the Chief Engineer. It is crucial that results and outcome of decisions, as well as implementation problems are periodically reported back to the respective councils.

3.12. NPP organizational and operational documents should have a hierarchical structure and contents, which should be specified by the quality management instructions. Documents should be logically and structurally related. Documents and their annexes should demonstrate that management activities and processes are organizationally and documentary complete.

3.13. The Chief Engineer should be request and obtain analyses and evaluation of the effectiveness of safety related activities, performed at the plant units.

3.14. The Chief Engineer should inspire in the subordinate personnel a spirit of openness in the discussions with the regulatory body with the objective to resolve NPPs safety issues.

STAFFING POLICY

3.15. NPP management should establish clear and principled arrangements in respect of personnel career development opportunities. Promotion should get only persons who have proved themselves in the operations, who possess the required operational experience, safety culture, management skills and are able to establish the appropriate organization and atmosphere for the implementation of activities to high quality standards.

3.16. The Chief Engineer should be informed on and should control the level of training, as well as means, practises and programmes and for staff training and retraining to maintain knowledge and skills.

3.17. NPP management should assess the impact of staff aging on the operations. Over time, monotony and routine at work can lead to reduced criticism (questioning attitude) in respect of working environment and process assessment. Preventive measures should be taken when there are indications of such weaknesses.

3.18. The Chief Engineer should foresee, organize and ensure staff succession, especially for staff performing specific activities and in case of changes in generations. Experience should be documented by development of written documentation – Operating and maintenance instructions, methodologies, guidelines.

ENGINEERING SUPPORT

3.19. To ensure safety and to improve design, increase system reliability and solve issues identified during the operation, plant management should use the services and products of proven (distinguished) scientific and expert organisations.

3.20. New technical and organizational measures should be consistent with the atest developments in science and technology.

3.21. The NPP structure should form competent structural units with the responsibilities to provide engineering support for the operations. These units should be staffed with experts, who have the operating experience and possess thorough knowledge on different aspects of safety assessment.

3.22. Experts in engineering support should have a clear view on conservatism, uncertainties of processes, assumptions, acceptance criteria, phenomena and mechanisms of aging, the current state of the issues to be discussed. The Chief Engineer should take care of the specialised training of the personnel in these units, through courses, seminars, joint projects with research institutes, missions, participation in missions, links with universities. All possible forms for improvement of professional knowledge and language learning should be used.

3.23. To get better understanding, support units should make a thorough review of external reports, which propose modifications or design improvements.

3.24. Engineering support personnel should: collect objective information on the status of SSC, operating processes and safety; process and analyze the information; highlight important aspects and make conclusions on trends; and as a feedback to inform the Chief Engineer in writing on the findings and proposals.

4. MANAGEMENT OF OPERATIONS

OPERATIONAL STRUCTURE AND DOCUMENTATION

4.1. The Regulation [1] sets as an operating condition the minimum amount of operating personnel for the different operational modes of the reactor installation. Operating licenses require that at least two qualified operators shall be present at the MCR.

4.2. Unit management principles should be applied in operational activities, where hierarchy of responsibility and accountability should be strictly followed as well as the reporting lines of unit operating personnel in respect of SSC operation. The work instructions should clearly divide responsibilities and subordination in both operational and administrative terms. The operating personnel should clearly understand the rules and should strictly follow the instructions.

4.3. Important for safety are the principles of undivided leadership in the management of activities, as well as the personal accountability for the performance and the results.

4.4. For consistent implementation of activities, interactions between the staff of different units should be described in the instructions and procedures in a clear and unambiguous manner. Hierarchy, responsibilities, command and communication should be defined and documented in the Rules of Procedure of the different departments and respective job descriptions. Instructions should clearly define written and verbal orders - for which activities and timeframe.

4.5. Lines of communication and documentation should be specified for cases of deviations from the OL&C or deviations of SSC operation from the requirements of operational procedures.

4.6. The instructions and procedures should describe the procedure for the interactions between different units in the preparation of information of various characters, the sequence for the information transfer, and the overall responsibility for the final document. Replacement responsibilities (name and position) should be explicitly specified for cases where the titular is absent.

4.7. Operational shift personnel should be trained on teamwork and the respective understanding and importance continuously promoted.

4.8. Instructions and procedures should arrange staff replacement in the conditions such as illness, inability to meet fitness for duty requirements or failure to fulfil assigned responsibilities.

4.9. Operational documents for implementation of activities, like instructions, switchover forms, check lists, duty forms or records should provide clearly documented by surname and signature the responsible officers for repetitive actions or performance of tests.

4.10. NPP (unit) operating managers in should document (by signature and surname) the periodic inspection of current operational documentation - operating logs and journals.

4.11. Responsibilities and authorities for reactor start-up after an event involving forced shutdown, stay in shutdown condition or large transients should be clearly defined by written documents. Procedures should exist to verify the safe state of the pant with set criteria and decision making responsibilities. Analyses of event causes should be carried out, conditions should be placed and respective corrective measures to prevent recurrence should be implemented. New reactor start-up would be possible only when it is demonstrated that it will be safe.

DAILY OPERATING CONTROL OF PROCESSES AND SSC

4.12. During normal operation, all the barriers established using the defence in depth concept, as well as the technical means for their control and protection shall be operable and able to fulfil their design functions. In deviation from these conditions, the unit shall be put to a safe state, in accordance with the operational documents.

4.13. Operating instructions should specify the minimum required operable equipment and the conditions of the SSC for different operating modes of the plant.

4.14. Equipment conditions should be checked during shift turnover and periodically during the shift through operators' walkdowns. The operating instructions should specify the equipment parameters, which to be recorded, additionally to the electronic logs.

4.15. The operating instructions and schedules for periodic walkdowns should specify the frequency for equipment inspection. Separate documents (appendixes, walkdown route maps) should indicate the scope of operators' walkdowns, as well as the procedure for documentation of observations.

4.16. Operators should be trained in practical skills to monitor and identify: parameters and alarms; instrumentation indications; setpoints' adjustment; leaks from flanges or gaskets; floor spills; position of valves; vibrations; availability of protective casings; grounding spots; corrosion abandoned parts; and other elements or characteristics required to verify the current status of the SSC. An important element is the effective cooperation between the local operators and MCR staff (e.g. reporting and documentation of deviations and inconsistencies; maintaining in operable conditions of communication means, constant and emergency lighting).

4.17. A program should be in place for monitoring and verification of the planned safety measures - valves locking, labelling or other equipment for isolation.

4.18. An effective system should be in place for recording and control of walkdowns by the supervisors.

4.19. A uniform system should be developed and adopted for identification (labelling) of the SSC of the entire NPP or unit, including operational tags and signs (labels).

4.20. Operating sectors should keep the adopted labelling available and in good quality for the various conditions and type of equipment. The licensee is responsible for ensuring clear identification and labelling of the safety systems and the safety related SSC. Equipment, facilities, pipelines and measuring equipment should have clear, readable and well-maintained identification.

4.21. Schedules should be established for periodic switchover of the working equipment and putting it into standby state (backup) or repair if necessary. Operators should be assisted by procedures and check lists for documentation of: operations performed, the condition of individual components, estimated parameters, interactions with other sectors and senior staff.

4.22. Instructions should specify the processes, particular responsibilities and actions to address identified deviations in the equipment conditions - appearance and abnormal behaviour and operational conditions.

4.23. Walkdowns to semi-service areas (restricted access) or inside the containment should be regulated by internal documents, should be justified and carried out only after preliminary preparatory activities - known radiological conditions and ensured personal protective equipment. Route maps should be in place and the radiation situation along the routes should be periodically measured.

4.24. The licensee should periodically verify that the ECR is in good condition and ready for use - documents, communications, alarm system and habitability. Access to MCR should be controlled and restricted.

4.25. Management of alarms at the MCR is an important feature in the safe operation of the plant. Information system should be checked each shift and operators should be trained to promptly and clearly identify deviations from normal operation. MCR alarms should be organized by priority. Their number, including alarm messages from computer systems should be minimized for any of the reactor states, including outage and emergency conditions. It is not permissible to deliberately turn off alarms.

4.26. The licensee should develop procedures to verify compliance and to take actions according to alarms occurrence.

ENSURING SAFETY DURING PERIODIC TESTING, UNIT START-UP AND SHUT DOWN

4.27. To verify compatibility between equipment actual and design characteristics and operability, scheduled tests should be performed regularly and before unit start-up.

4.28. An important principle in the tests is to simulate conditions close to the real ones, which to initiate the automatic start-up of the safety important SSCs .

4.29. Operational testing documents - programs, procedures and check lists should specify the responsible staff, acceptance criteria, actions following deviations from expected performance of SSC, documentation requirements, data analyses, trends and respective conclusions.

4.30. The requirements for storage of test documents should be formalized. The analyses of equipment conditions and trends in SSCs performance should be evaluated by experts from the unit for engineering support. Decisions on the actions for restoration to the desired state should be made by the maintenance experts.

4.31. An important part of the SSCs tests are the functional tests during unit start-up after a planned annual outage. They should prove the preparedness of the SSC to perform their design functions. The same applies to design modifications with installation of new systems or systems replacement with modern ones. These tests should cover all possible combinations of SSC trains using detailed programs and check lists.

4.32. Test program should clarify responsibilities and processes for amendment of the approved documents.

4.33. When implementing a non-routine activity, test or experiment for the first time, safety assessment and justification should be carried out. OL&C for the particular case should be developed as well as a program or procedure to carry out the activity. The procedure should provide actions for cases of deviation from the expected OL&C or SSC performance.

4.34. In carrying out safety related experiments for the first time, there should be an independent scientific assessment, sufficient conservatism and questioning attitude should be applied, and complete clarity should exist in respect of the degree of uncertainty of the processes and results.

4.35. Experiments and activities without a clear need and without justified objectives and expected results shall not be performed at all. This applies also when they could lead to an unexpected plant state.

4.36. All testing programs should provide for safety provisions for the case of unforeseen or beyond design development of the test.

4.37. Responsibilities and communications should be clearly defined in writing. Test conditions and equipment used should comply with those required by the approved documents. The staff participating in the experiments should be fully aware of the nature and magnitude of the hazard and the respective consequences.

4.38. Special programs should be developed, accordingly approved and implemented to demonstrate the safety of the reactor core, in respect of reactivity coefficients, departure from nuclear boiling other variables that are important for the safe start-up and operation of the reactor. During the campaign, parameters indicating the safe operation and those that are to be kept in reasonable limits should be continuously monitored.

4.39. At start-up, the operators should be trained on and be aware of the nuclear risks at the installation due to the lack of passive protections of physical character (missing backup connections). In this mode, controlling physicists have the leading role and responsibility as they monitor the parameters of the nuclear installation.

4.40. During start-up tests, the operability of safety devices of the primary and secondary circuit should be checked, availability of safety margins should be demonstrated (margins of safety parameters in respect to the safety limits as specified by the technical specifications).

4.41. Safety devices for coolant control (primary circuit) should be tested with the real flow of coolant at low parameters. Testing in start-up, shutdown and maintenance and adjustments conditions should be performed using procedures and devices of the manufacturer of the safety devices.

4.42. Unit start-up is possible only after successful testing and readiness, without exceptions, of all systems, measuring devices, personnel and parameters as required by the technical specifications.

4.43. At unit start-up and nominal power should be controlled whether the main unit parameters are within the design limits, as set out in the table of allowed operating modes of that unit. This ensures adequate behaviour of the neutron-physical and thermo-hydraulic parameters of the components of the reactor core in normal operation, deviations and accidents.

4.44. Control technical means and methods, which prove the reliability or determine equipment lifetime should have certificates for applicability to nuclear power and should be validated. The respective staff should be trained and should possess the required qualifications.

4.45. The documents accompanying the selected control technology (e.g. qualification of equipment, procedures and personnel) should be covered by the quality management system.

4.46. The technical measuring equipment, test and calibration stands should have adequate accuracy, scope, scale with internationally accepted measurement units of readings and should be metrologically tested.

4.47. When for various reasons, resolution of a safety issue is not possible to take the measures specified by the instructions or the design, compensatory measures should be implemented as an alternative solution. These measures should be developed for this particular case and should be approved by the Regulator. These measures may be of different character, like special procedures, additional training and examination, technical measures proposed by relevant studies or resulting from decisions in similar cases from the own practice or international experience, as applicable.

4.48. Operators should pay due attention and responsibility in shutdown and refuelling reactor modes, where operations take place related to taking out of service of safety systems or involving important switchovers, which may affect: reactor control; temperature regimes influencing the metal of the coolant boundary or the reactor; departure from nucleate boiling ratio, or the integrity of nuclear fuel.

4.49. For shutdown, refuelling outage and start-up modes, instructions, procedures and check lists should be developed for verification and documentation of the conditions of those valves that secure nuclear safety at that state. Switchovers should be performed using specially developed Manipulation Lists.

4.50. Operating instructions for SSC (or by other form) should specify the obligations of the operating staff to record the parameters in the operating documentation or in specific logs/journals during normal operation, abnormal operation or testing. Tests having design limitations, such as the number of cycles; parameter values; the number of deviations from normal operation and design basis accidents should be recorded in special registers.

4.51. SSC tests should be performed in accordance with the scope and frequency as defined by the schedules or by the TS. Some regulations or NPP external documents allow for short delay in testing. However, safety culture does not tolerate administrative intervention or undue delay in activities.

4.52. Plants should have a procedure for response to identified deviations from the design values of the characteristics and the performance of safety important SSCs, during tests or operations. The procedure should specify the processes for a new validation of the affected functions. NPP should analyze the situation and the possible consequences and should take actions to restore the functions and SSC characteristics within the operational limits and conditions. Appropriate actions could include inspections, testing or maintenance and repair, as appropriate.

PERFORMANCE OF HAZARDOUS OR SAFETY RELATED ACTIVITIES (OPERATIONS)

4.53. NRA legal documents do not provide a definition of those activities or operations. However, Annex 15 of the TS includes lists of dangerous nuclear and maintenance operations. Based on the definitions of nuclear accident and nuclear safety, that type of activities involve any case where in violation of safety rules may result to an event leading to deviation, incident, accident.

4.54. Dangerous nuclear activities are those that can lead to a nuclear accident. They are defined and listed in the operational documents (Ts or instructions). As a rule, these activities are carried out in shutdown mode.

4.55. A basic requirement for ensuring nuclear safety in hazardous or safety related activities is that they should be adequately analyzed and controlled to reduce the risk of harmful effects of possible violations or failures. It is important to ensure that work orders for such activities have remarks or other indication that the planned activities fall in this category.

4.56. Routine activities should be implemented with caution, such as blowdown of impulse lines, replacement of sensors, and replacement of electronic components or relays in safety important circuits, checks of signals in the circuits. In these cases, at least two levels of protection should be provided - one is the reliability of actions to secure the respective elements and circuits and the second level – the created for the test new chains and status of instrumentation used.

4.57. If probabilistic analyses are used for decision-making at NPPs, it should be of sufficient quality and scope and should be developed by analysts with appropriate skills. Risk analysis should be used to supplement the deterministic approach. The licensee should assess the risk of any change in the state of the reactor installation, significant modifications or safety related operations. Operating personnel should be familiar with the risk assessments.

4.58. Safety important activities should be implemented by following programs and procedures, to ensure that the plant is operated within the established operational limits and conditions. The leading role of MCR operators should be recognized for organizing, conducting, monitoring and evaluation of tests and important safety operations and the overall operational aspects.

4.59. The programs and procedures should describe the objectives, technical and organizational measures and monitoring criteria for proper performance. Responsible individual with the appropriate qualification should be determined.

4.60. Programs and procedures should provide a form for recording the sequence of switchovers, room number, valves conditions or changes in conditions, orders given or received, and registration of all technological parameters which may affect the operating limits and conditions.

4.61. A fundamental safety principle is never to perform two or more nuclear hazardous activities in parallel. It is important that this principle be followed by operators in reactivity control operations and during refuelling of the reactor core.

4.62. Activities should not be performed, if the conditions from analyses have not been fulfilled.

4.63. Non-routine experiments, activities or tests, not included in the existing operational documents, should be implemented following assessments and using programs and methods developed for the particular case, after approval by the regulatory authority.

4.64. All routine or non-routine nuclear safety or hazardous activities, should be evaluated for their potential hazards and the associated radiological consequences.

4.65. Staff actions during the operations should be specified in the written procedures developed. Verbal communications should be limited to a minimum and should include confirmation for correct understanding (2-way and 3-way communication). Best practices worldwide in respect of verbal communication are the 3-way communication: order - understanding of the order - the confirmation of correct understanding.

4.66. Appointed decision-makers and individuals performing such activities should clearly understand their responsibility and the potential consequences should avoid compromise and should have the required qualification. For this purpose, they should know the programs and instructions should strictly follow procedures and should apply conservative approach in thinking and actions.

4.67. Environmental conditions that can affect the human factor in the performance of activities should be clear and well understood. Pre-job briefings are applicable to such cases on working conditions and their nature, hazards, expected results, possible behaviour of SSC and actions in response to deviations.

4.68. Managers should consider and control the effects from fatigue.

4.69. During operations, the staff should be prepared for sudden changes and should possess the required safety culture.

OPERATIONS WITH NUCLEAR FUEL

4.70. The licensee should provide conditions and control that only certified by the manufacturer nuclear fuel is loaded into the core. Design features and fuel enrichment should be in accordance with design specifications and should be approved by the regulatory body. Same requirements apply to new fuel design or changes in core configuration.

4.71. The licensee should develop procedures for supply, verification, receipt, inspection, loading, use, displacement, replacement and testing of fuel and core elements. Fuel related programs should be in accordance with the design assumptions and should be submitted to the regulatory body if necessary. When refilling the core, calculations and measurements should be performed to confirm that core characteristics meet the acceptance criteria.

4.72. The licensee is responsible for developing a program for reactivity control in accordance with strict quality system. All actions like decisions, planning, evaluation, implementation and control of operations, which affect the fuel impact on reactivity, should be taken according to approved procedures and in respect of adopted limits for the core.

4.73. In-depth core monitoring program should be performed to ensure that core parameters are being controlled and analyzed to identify trends and detect unusual or unexpected behaviour. The real conditions should be in accordance with design requirements for the core. The values of key operating parameters should be recorded and stored in a logical, consistent and retrievable manner.

4.74. Effects on reactivity should be considered and carefully controlled to ensure that the reactor is operated in accordance with prescribed operational limits and that design conformance is maintained.

4.75. Operating procedures for reactor start-up, operating at power, shutting down and refuelling should include safety provisions and restrictions to maintain the integrity of fuel cladding and to comply with the operational limits and conditions for the entire duration of fuel use.

4.76. To verify that fuel cladding is held tight in all operating conditions, the respective radiochemistry data should be systematically analyzed and securely stored.

4.77. Appropriate methods should be applied to detect changes in coolant activity. Data analysis should be performed to determine the nature and severity of fuel defects, the location of defects, probable root cause and to determine corrective measures.

4.78. Procedures should be developed for use and handling of fuel and core components to ensure that irradiated and fresh fuel is properly manipulated, controlled, stored on site and prepared for shipment off-site. Plans for storage should be submitted to the regulatory authority if necessary.

4.79. Particular attention should be paid to operations of lifting of the reactor head before refuelling. Reliable control should be ensured, nuclear safety should be provided in diversified ways, and CRs should be separated from the drives. Specific access and control should be organized during refuelling, technological measurement and before sealing the reactor to prevent falling of foreign objects into the core.

4.80. Packaging, transport and shipment of unirradiated and irradiated fuel should be performed in accordance with relevant national rules for the internal transport. In case of an event with international transport, the IAEA requirements on safe transport of radioactive materials should be applied.

4.81. Before any nuclear fuel manipulations, the licensee should ensure that there is authorized, trained and qualified personnel available, who is responsible for on-site control and manipulation, according to written procedures. Access to fuel storage facilities should be limited to authorized personnel.

4.82. Detailed reports should be stored, as required, for storage, irradiation and transfer of fissile material, including irradiated and unirradiated fuel for a period of at least the time as required by the legislation.

OPERATING DOCUMENTATION

4.83. In compliance with the quality management requirements, the licensee should develop detailed administrative instructions, which to contain rules for development, approval, periodic review, validation, renewal and revocation of operating documents (instructions and procedures, check lists, programs).

4.84. The general requirements to the operational documents are that they should be clear and meaningful to the maximum extent possible, verified and validated.

4.85. An important conclusion coming from the best practices is that operational documents should contain all necessary attributes, but should be as short as possible.

4.86. It is necessary to have developed complete operational documents for the reactor installation and the auxiliary equipment for normal operation, deviations and accident conditions, in accordance with licensee policy and in conformity with regulatory requirements. The level of detail of the specific documents should be consistent with the objectives.

4.87. Documents should be included in a list and should be available for use at the MCR and elsewhere where necessary. Access to them should be provided also to the Regulator. Strict compliance with written procedures should be an important element of plant policy.

4.88. The documents for normal operation should ensure that the plant is operated within the operational limits and conditions.

4.89. Instructions for response to deviations from the normal operation, design basis accidents and beyond design basis accidents (or severe accident management guidelines for beyond design basis accidents) should be developed. Instructions, based on analyzed particular events or in combination with the symptom-oriented instructions for beyond design basis accidents should be used as appropriate. Both instructions should be based on analyses, which have been documented. Severe accident management guidelines should be developed for extreme events.

4.90. Operational documents and their appendices should be of controlled documents type and should be approved and periodically reviewed and revised as necessary, to ensure their adequacy and effectiveness. The documents should be updated periodically to take account of operational experience and current status of plant configuration.

4.91. A system should be established for administration and control of support materials to be used by the operators. Through the control system, the operators should be protected from use of unauthorized materials (unapproved, outdated, illegal) and tools (not approved - instructions, notices, signs, technical means, local boards, measuring devices) at the workplaces. The system should ensure that operators' support means contain correct information, which is periodically updated, reviewed and approved.

4.92. The licensee should maintain a policy of minimum use of temporary facilities and conditions of the SSC. If their need have been repeatedly confirmed they should be converted to permanent.

4.93. Operating documents should include a requirement for close communications between the operating and maintenance personnel, which is of extreme importance for safety, especially in changing of the status of the installation, performance of tests after maintenance, identification of defective equipment, assessment of SSC conditions.

4.94. Operational and maintenance staff should be familiar with the operating and emergency instructions (procedures). For response to emergency situations, the personnel should be trained using the existing emergency instructions. Where appropriate, simulator should be used for the training. Periodic training should be conducted on how to use instructions and how to transfer to instructions in respect to design basis accidents. Interventions, in case of severe accidents, to restore safety functions should be planned and practiced. Staff training activities on accident response should be documented.

5. OPERATING LIMITS AND CONDITIONS (OL&C)

5.1. "Operating limits and conditions are a set of rules specifying the limits of parameters, functional capabilities and performance of SSC and the authorized staff to ensure the safe operation of the nuclear power plant" (definition 38 of the Regulation [1]).

5.2. The licensee should provide the operational safety of the nuclear power plant in conformity with the operational limits and conditions (OL&C), which should be approved by the regulatory body and should be specific to the particular installation or unit.

5.3. Operational limits and conditions are the basis, on which the licensee obtains the right to operate a nuclear installation within certain limits and conditions.

5.4. The operation of the plant within the operational limits and conditions should eliminate cases that lead to anticipated operational occurrences and should limit the consequences of such events if they occur.

5.5. Compliance with the operational limits and conditions ensures that the plant is operated in accordance with design assumptions, purpose, and licensing conditions.

5.6. Operational limits and conditions should reflect design requirements and results, should be confirmed by successful experiments during plant commissioning, and should be described in the Final Safety Analyse Report (SAR). Before initial plant start-up, the OL&C should be submitted to the regulatory body for review and approval.

5.7. Parameters' limiting values and the conditions, under which the operating personnel controls safe operation (through direct or indirect measurement) should be specified in a separate document called Technical Specifications. The purpose, need and justification of any operational limit or condition should be described in a supplementary document. Both documents should be available at least for the operators at the MCR and the ECR.

5.8. Limits and operating conditions, which can not be directly or indirectly controlled by the operating personnel, or which relate to data and characteristics of SSCs not managed directly by the operators should be reflected in the operating instructions.

5.9. OL&C should periodically reviewed and reassessed for compliance with the operating experience, development of science and technology, should be compared with the results of safety analysis and should reflect the changes to the SSC. OL&C could also be modified on the basis of own or foreign experience.

5.10. OL&C should include requirements to all operational modes conditions of the reactor installation, as specified by the Technical Specifications - normal operation, shutdown state, refuelling and the transitional states in-between.

5.11. OL&C for each mode should include:

- Safety limits;

- Parameter values for the actuation of the safety systems;
- Operating limits (for normal operation or other basic modes);
- Operational conditions (quantity of safety important SSCs, features, performance requirements, maintenance, testing, monitoring);
- Operating personnel prompt actions and response time in deviations from the limits and conditions for operation (parameters' value or number of safety important SSCs available);
- Minimum number of qualified operating personnel for MCR, ECR or refuelling.

5.12. Operational staff involved in direct supervision, should have detailed knowledge of OL&C and should be trained to take the appropriate actions. Acceptable margins should be established between the values of normal operation parameters and the protection setpoints of the safety systems to avoid unnecessary frequent actuations.

5.13. NPP should develop and implement a program for supervision of compliance with the OL&C.

5.14. In the event of deviation from the operational limits and conditions, responsible personnel should perform immediate actions for recovery into the OL&C range or transfer of the nuclear plant into a safe state, as specified by the technical specifications or the emergency procedures (actions in deviations or SBEOP).

5.15. Responsibilities and authority for reactor start-up after an event involving shutdown, forced outage or large transients should be clearly defined in written documents. Event cause analyses should be performed and conditions and criteria laid down, as well as corrective measures to prevent event recurrence should be implemented. New reactor start-up is possible only when justified that this will be safe.

5.16. The licensee should have a policy of strict compliance with and operation within the established OL&C. When circumstances require operation outside the OL&C, written guidelines or instructions for these actions should be developed, including restoration within the OL&C, based on relevant analysis. In these cases, the instructions should require NRA consent (exemption) for the temporary changes in the OL&C.

5.17. NRA will not tolerate any practice of continuous operation within temporary OL&C.

6. MAINTENANCE, TESTS, SURVEILLANCE AND CONTROL OF SAFETY IMPORTANT SSC. ANNUAL OUTAGE. LIFETIME MANAGEMENT

MAINTENANCE PROGRAMMES

6.1. Nuclear power plant should develop, periodically review and implement programs for maintenance (repair, testing, control of technical conditions and inspection) throughout the lifetime of safety important SSCs, in accordance with design requirements.

6.2. Developed programs should include planned, preventive, and corrective actions to ensure design availability and preparedness of the SSCs during their lifetime. Control should be exercised over the deterioration (degradation) of safety system characteristics with the objective to prevent their failure and to preserve their ability to fulfil design safety functions within the established acceptable criteria. Preservation of the integrity of the protective barriers (part of defence in depth) is a primary obligation of the licensee.

6.3. Maintenance activities of the SSC should be executed in accordance with such standards and with such frequency, which to be consistent with: their safety importance; input deck for probabilistic analysis; design reliability and availability; assessment of their aging ability; manufacturing requirements; operating experience; and tests results.

6.4. Maintenance programmes and activities of the SSC should be in conformity with the approved operating limits and conditions. Activities should be able to detect and correct any deviations from normal operating conditions before propagation into an event with significant safety consequences. Actions that secure the reliability of SSCs ensuring the safety of NPPs, should be carried out with priority.

6.5. Plants should develop written procedures for the implementation of different activities to support the SSC. Procedures should be developed, periodically reviewed, modified, validated, approved and distributed in accordance with the quality management system.

6.6. The data collected for failures of SSC and data from maintenance activities (testing, maintenance, repair, inspection and control) should be registered, put in systematic order and appropriately stored to demonstrate that performance of SSCs is consistent with design expectations and assumptions for equipment reliability and availability. Data analysis should be used for lifetime management of SSC. Documentation of activities should ensure traceability of occurrences and processes over time, which would be useful in analyzing SSC lifetime.

6.7. Plants should apply a comprehensive approach for the analysis of possible failures of SSCs and for identification and management of maintenance activities, including probabilistic methods as appropriate.

6.8. New approaches to lifetime analysis and management, as far as they could change the applied practices, should be introduced after careful consideration and appropriate approval.

MAINTENANCE PLANNING, IMPLEMENTATION AND QUALITY CONTROL

6.9. An important element for the implementation of activities is the timely planning and preparation of the needed resources so that preparedness for the upcoming activities could be declared.

6.10. Plants should develop and implement a comprehensive and thorough system of planning and quality control activities of SSC maintenance.

6.11. The activities scope and timeframe should be clearly defined in long term and short-term. Activities should be permitted for implementation following the approved procedures. They should be carried out in a safe manner with the required quality and should be documented in accordance with developed procedures.

6.12. Management could change programs and timeframe of activities only when they have been justified and documented by written decisions. Reasons for changes may be: accumulated experience feedback; SSC conditions; manufacturer recommendations; performance of alternative measures in delayed supplies; analysis of activities implemented in the previous year. Justification of decisions for modification is essential to the safety systems.

6.13. Procedures should specify the personal responsibility for each activity.

6.14. Procedures should be developed for the implementation of quality control, which to describe the review process.

6.15. It is useful, that a structural unit for independent quality control be established inside the maintenance department, which to independently supervise contractors. Welding activities should be subject to intensified control.

6.16. All elements of the activities implementation process should be subject to control - input control of supplied equipment; storage of spare parts; control of the qualification of external and internal contractors; workplace culture; maintenance maps, sketches, drawings, procedures; tools used; pre-job briefings conducted; implementation reports. Used tools and materials should be provided with the required certificates, quality and accuracy in accordance with maintenance procedures.

6.17. Plants should have a system for acceptance of contractors' activities. To assess implementation quality, appropriate criteria and indicators should be developed.

6.18. Procedures should describe actions to be taken upon detection of deviations from the acceptance criteria for maintenance, testing, supervision, conditions checks or inspection.

6.19. Organization of activities should be in compliance with the so called work ordering system, which determines the procedures and documentation of access to workplaces, implementation of activities, and transfer of working areas back to the operating staff. Maintenance personnel should be trained to know and strictly follow the safety measures. Safety measures should be applied to the same extent and effect in emergency calls or situations.

6.20. Requirements to the staff of the external contractors should be the same as these for the staff of the licensee. The good practices of short briefings should be applied before, after, or in interruption of the work, as well as during shift change on: dangerous adjacent areas; precautions taken; provision of protective measures during work interruption or restart, evacuation pathways, rotes of fire protection engines, radiological conditions, constraints, actions in unforeseen circumstances, provided control points of suspension, acceptance criteria; or conditions for putting back into operation of the repaired SSC.

6.21. The system for control of maintenance activities should ensure that SSCs are taken out of service before the repair, testing, control or inspections, in compliance with the required permits and the establish operational limits and conditions. That system should guarantee that after repairs or other maintenance activities the SSC could be put back to service only after permission by the operating personnel. The bases for that permit are documented verification of performed functional tests and configuration, corresponding to the established operational limits and conditions.

6.22. Procedures should arrange and ensure the interactions and coordination between operating personnel and the various sectors involved in the maintenance activities - specialists in thermo-mechanical equipment, electrical equipment, control and protection systems, radiation protection, construction, physical protection, fire protection.

6.23. The licensee should develop and agreed with the operator of the national grid procedures (for planned and emergency situations) for management of SSCs, which are related to connections of the plant with the grid.

6.24. To perform maintenance while at power, the licensee should provide for the required defence in depth. Where possible, it should be demonstrated using probabilistic methods that the risk of implementing the activities is acceptable.

6.25. Plants should develop procedures and should maintain a system for documentation, management and elimination of deficiencies and failures (defects) in the SSC. Documentation of SSCs deficiencies or failures is responsibility of the shift personnel.

6.26. Corrective actions to address deficiencies or defects in SSC should be taken as quickly as possible in respect of their safety importance, and in conformity with the operational limits and conditions.

6.27. Plants should develop and implement procedures for procurement, acceptance, storage and use of materials, spare parts and components.

6.28. The procedures should include requirements on performance and quality of supplied components to ensure safety in accordance with the applicable standards and plant design.

6.29. Upon delivery of complex systems or to implement modifications of safety important SSCs, the licensee should require from the supplier or manufacturer the following:

- Certificates of qualification of the components and the device as a whole, according to the intended purposes and conditions;
- Documents concerning the qualification and metrological verification of the control systems (reference samples, control stations, software) to be used for the tests and supplied by the manufacturer.
- Results of manufacturing tests of the device, where witnessing of the tests by a licensee representative is advisable;

- It is recommendable that both the manufacturer and the licensee participate in the assembly and testing on-site (manufacturer is responsible for its product and the licensee is gaining operational experience).

6.30. The licensee is obliged to carry out strict incoming (entry) control of supplies, without a formal approach and without time limits.

6.31. Plants should provide and maintain suitable conditions for storage of spare parts supplied. Procedures for storage should provide access to manufacturer certificates, entry control protocols, and separate storage of supplies for safety systems. Fit and unfit, scrapped or used parts should not be stored together.

PLANNING AND ORGANISATION OF ANNUAL OUTAGES

6.31. Based on long-term planning and current status of the SSC, the plant should develop a program and a timetable of the activities to be performed during the PAO. Planning activities for the PAO is an ongoing process of providing for the needed spare parts and qualified contractors, and making the proper arrangements for implementation of planned activities safely and of high quality within the time available.

6.32. In planning and implementing activities, priority should be given to safety and to maintaining plant configuration in conformity with the operational limits and conditions.

6.33. Plants should develop and implement procedures and programs for management of PAO activities, associated with: keeping maintenance schedules; ensuring safe conditions for activities; compliance with operational limits and conditions and fire protection requirements.

6.34. To provide safety at work, measurement of background radiation should be done on certain routes in the reactor building and the turbine hall, as well as in places where maintenance is performed, personnel gathering points and walking corridors. Cooling, fencing and other specific industrial safety measures (lighting, temperature, humidity, use of personal protective equipment) should be provided. Measures should be periodically checked for effectiveness and compliance with them.

6.35. The tasks, authorities and responsibilities of groups and individuals, engaged in the preparation, implementation and evaluation of activities should be specified in the procedures and should be followed by both plant staff and external contractors.

6.36. Interactions between different groups of NPPs specialists, as well as between plant staff and external contractors should be clearly defined. Shift personnel should be constantly informed about the current status of maintenance activities, changes in structures and testing.

6.37. The plant should have as a priority the optimization of radiation protection of personnel involved in radiation hazardous activities. An integral part of the PAO programs and procedures should be the measures for: radioactive waste management and waste reduction; work with dangerous chemicals; and compliance with fire regulations and requirements. Plant personnel and external contractors should be informed to follow these requirements.

METAL CONTROL, TESTS OF SSC AND BUILDING STRUCTURES

6.38. Plants should periodically review the status of base metal and welded joints of safety important SSCs in respect of aging caused by cyclic loading, electrochemical corrosion, effects of neutron flux, seismic and construction loads. These impacts and processes lead to changes in the structure of metal or other structural elements that result in the reduced availability of structures.

6.39. The condition of the base metal and welded joints of safety important SSCs should be periodically controlled by qualified non-destructive testing and in accordance with IAEA standards. The qualification relates to the control means, methods, and personnel involved. Developed procedures and control methods should cover all safety important SSCs and should include requirements for reliability and effectiveness in detection of defects.

6.40. Plants should develop and use a specific system for quality management in respect of activities related to metal control of SSC. The system should provide for periodic review and validation of control methods and mean, staff retraining, and data storage system.

6.41. Plants should perform periodic testing of: tightness of coolant boundary, containment tightness, control of the pre-stressed strain state of the containment shell, geodetic control of the relative displacements in structures due to seismic impacts settlement of foundations over time.

6.42. Control procedures should provide processes and actions to address the deficiencies from standards or acceptance criteria, identified during the test or control activities.

6.43. Licensee intending to operate the plant beyond the design lifetime should promptly develop and implement a program and carry out research and evaluations to justify the residual lifetime of the SSC. The program should be developed in cooperation with the General Designer of the plant and should be submitted to the NRA for review. Program should take into account the experience of other licensees, who have successfully demonstrated the possibility of extending the design lifetime of nuclear installations.

6.44. The licensee should maintain an aging management programme to identify all the mechanisms of aging of safety important SSCs , to determine the possible consequences of the processes, and to specify possible measures to restore the operability of affected SSCs. Aging management program should be understood as an integrated approach to monitoring, identifying, documenting, analyzing the aging of SSCs, leading to reduced performance, as well as the implementation of corrective measures to restore the design features.

6.45. The analysis of the SSC lifetime should consider the fact that aging mechanisms and processes are not entirely clear yet, but should also take into account the degree of reliability of the results and effectiveness of different control methods. In this case, deterministic methods to evaluate the situation should be complemented by probabilistic assessments.

6.46. Aging management of the reactor vessel and its welded joints should consider all relevant factors, including increased brittleness, thermal aging and the fatigue of a long operation. Received current data should be compared with the expected design and estimated values of the indicators for the entire lifecycle of the vessel.

LIFETIME CONTROL AND MANAGEMENT

6.47. Current technologies, in respect of determining the lifetime in the design, manufacturing and installation, are not able to completely ensure the expected operating lifetime of SSC for the entire plant life. Therefore, the licensee should establish and implement technology and tools for systematic monitoring of resource characteristics (resource assurance system) in order to maintain the reliability of SSCs and respectively plant safety.

6.48. Lifetime management is a concept that is associated with aging management of SSCs and safety management, which ensures safe operation of the NPP throughout its operating life. Both processes constitute the content of the concept of plant lifetime management.

6.49. Aging management includes the commitment and activities for studying the phenomena and processes of aging of SSCs materials, deterioration of the quality parameters of SSCs (degradation), and obsolescence of components and objects as a whole, in order to reduce their negative impact on plant safety and economic indicators. For this purpose, methods and means should be developed to reduce the impact of aging and to ensure continued operability of SSCs. These activities are part of measures to maintain and even increase plant safety, which constitutes the process of safety management.

6.50. To determine lifetime, data is needed from: the design (plasticity, fatigue resistance, strength, fragility, sensitivity to loss of integrity, the influence of neutron flux, corrosion, acceptance level of deformation at the early design stage); the SSC manufacturing (mainly through the selection of materials and manufacturing technology); installation; commissioning (pre-operational adjustments); entry control; control and monitoring during operation.

6.51. Lifetime data should be collected:
- At the equipment entry control stage and the accompanying technical documentation;
- By controlling the physical state of the SSCs metal at reasonable periods of time during the operation, for which due to the slow development of the negative processes the resource limits will not be reached;
- By NDT to detect defects in the SSC metal as loss of integrity - visual, capillary (magnet-graphic method), ultrasonic, radiography, eddy current testing and other methods.

Lifetime Control to Support Operations

6.52. Control of lifetime should begin before unit commissioning and should continue periodically during the operations. The scope and type of control of the SSC should be determined by the influence of these SSCs to safety.

6.53. Control during the operation should be done by controlling the lifetime characteristics, determining the occurrence of limiting conditions – form deformation (geometry change) due to changes in plasticity, corrosion, mechanical or corrosion induced wear out, the occurrence of cracks or untightness below the surface.

Subjects and Methods for Control of SSC Lifetime

6.54. During the operation should be controlled:
- Welded joints, anticorrosion overlaying, basic materials in areas of stress concentration and such located in front of the core, bending pipelines, sealing surfaces of vessels and

heads, restraints, studs, metal in threaded joints and pressing ring pedestals, collectors' welded joints, SG tube bundles, sections with water - steam phase transitions, welded sections of transitions between joints and vessels, connecting pipes and tees to vessels;
- The mechanical properties of the metal through periodic review of witness samples, metal samples (destructive method), determination of hardness;
- By measuring of geometry during the operation and comparison with the values of entry control by using mechanical or optical measuring means, thickness gauges, UST;
- The results of hydraulic tests of strength and ductility;
- Worked out hours.

Assessment of Rest Lifetime

6.55. Described methods for lifetime control could be used to determine the lifetime and respectively the possibilities for operation till the next controls. They could not identify the limiting characteristics, the actually remaining resource, and the limiting lifetime of the SSC.

6.56. Residual lifetime should be determined using the method of "evaluated assessment of remaining lifetime" by using data from:
- actual state of the metal (analysis of the likelihood of remaining undetected defects);
- real operational impacts;
- deterministic assessments of the lifetime (data on temperatures, neutron irradiation);
- integrated assessment of the residual lifetime in probabilistic terms.

6.57. Data about metal conditions relate to:
- Probability patterns of flaw detection methods and reliability of control (application of methods for reliability testing using test specimens with hidden defects);
- Analysis of results repeatability at constant conditions;
- Comparisons of results from different methods of control;
- Analysis of human factors impact on the control outcomes;
- Control technology - duration and frequency of scanning.

Prerequisites for Lifetime Extension during Operation

6.58. Physical properties of SSCs, which determine lifetime characteristics, are objective in nature, but their estimates are subjective in nature.

6.59. Objective prerequisite for justifying operation continuation (based on detailed lifetime estimates) consists of the conservatism included in the design (actual lifetime is greater than the demanded and designed). Selection is made at the design stage, on one hand of minimum tolerable stress and maximum load operating conditions, and on the other hand - control methods improve over time in comparison with design time.

6.60. The following ways are available to influence lifetime:
- Search and justification of margins in the strength and the designed initial lifetime;
- Implementation of compensatory measures;
- Repairs;
- Reconstruction;
- Change in operating conditions;
- Replacement.

6.61. Justification for extended service life of SSCs is possible by solving problems and algorithms (solving lifetime problems) that use:
- Justification of economic and social aspects;
- Justification for the new lifetime, based on knowledge of the strength of materials;
- Application of technologies for systematic assessment of the lifetime, reliability and safety.

6.62. After the assessments of SSC remaining lifetime and selection of measures to secure the new operating life, analysis of SSC safe operation should be performed using deterministic and probabilistic assessments of SSC strength, resource and reliability.

7. MANAGEMENT OF MODIFICATIONS

CONFIGURATION MANAGEMENT

7.1. Nuclear power plant should establish and maintain a configuration management system to ensure consistency between the design requirements, the actual configuration state and the supporting documentation.

7.2. Configuration control should ensure that modifications of the plant and the safety important systems are clearly defined, designed, monitored, evaluated, implemented and documented. Comprehensive control should be provided to manage the changes in configuration resulting from: change of conditions, maintenance and repairs, upgrades of physically and morally degraded components and technologies, operational experience, developments in science and technology.

MANAGEMENT OF MODIFICATIONS

7.3. Plants should establish and maintain control of changes (modifications) in SSC as part of configuration management program.

7.4. Modifications may arise from and affect various aspects of the operation of NPPs - structures, systems and components, operational limits and conditions, procedures (operating instructions and other documents) and organizational structure.

7.5. Modifications should be appropriately justified and should meet the requirements of legal documents. They should be evaluated by the licensee according to their importance to safety. Prior implementation, planned safety related modifications should be submitted to the regulatory body for assessment of their safety significance and compliance with the regulations.

7.6. Plants should establish and follow a system for assessment of modifications, which to control the different modification stages - detection and problem formulation, design, evaluation, approval and licensing, implementation and documentation.

7.7. To ensure systematic evaluation of modifications, the licensee should develop detailed questionnaires (supplementary to the procedure) in respect of modification impact on various aspects - operational, risk assessment of the change, radiological impact, direct or potential impact of the operation or of failures on other structures or safety functions, control access possibilities, maintenance, fire risk, compliance with regulatory requirements, etc. Modifications submitted to the NRA for assessment should be accompanied by the answers to the detailed questionnaires part of the NPP assessment.

7.8. Implementation of design modifications is not possible without NRA authorisation, even when the legally defined deadline for regulatory decision making has expired.

7.9. Modifications control should ensure quality in design, safety assessment, implementation and testing of all permanent and temporary changes. Effects of the modification on human factors and performance, as well as on organizational factors should also be analyzed and properly considered. Modifications control should ensure compliance with all requirements of the applicable standards and the regulations.

7.10. The IAEA recommends that control over modification be carried out in accordance with NS-R-1 [9].

7.11. Temporary modifications should be limited in time and number to reduce the cumulative effect on safety. The system should include requirements for clear identification of temporary changes - documenting the location, specific labelling, and periodic review. Formal system should be available for timely notification of the operating staff about temporary modifications and their safety consequences.

7.12. The duration of temporary modifications should be the end of the coming PAO. When needed for a longer period they should be made permanent. Monthly reports should be prepared and submitted to the Chief Engineer on the conditions of and needs for temporary modifications.

7.13. Modifications control system should include requirements for periodic review and revision of documents, plans, computer codes and on the spot verifications.

7.14. Plants should develop a procedure for revision of the documents, which need to be reviewed as a result of implementation of planned modifications.

7.15. Before modifications commissioning or reactor start-up following modifications, staff should receive the required training and the operating documents should be revised (updated, corrected).

7.16. The procedure should cover requirements on the timeframe and responsibilities for review of all documents being affected by the modifications.

7.17. When the modifications are required or are intended to achieve SSCs reliability better than the design one, an independent assessment should be performed to solve the issue. Assessment may include analyses of the situation and proposal a new design solution, which consists of design stage, manufacturing, installation and commissioning of the new solution. Due to the inherent uncertainty of the process, the assessment should highlight the availability of sufficient conservatism.

7.18. The use of authorized scientific and design organizations for independent assessments, solutions of technical problems or improvements in operational documents is an advisable and common NPPs practice when justifying operational modes and issues or when modifying safety important SSCs.

8. USE OF OPERATING EXPERIENCE

8.1. A system should be established and maintained for recording and reporting of events in accordance with the Regulation on procedures for notifying the Nuclear Regulatory Agency of events at nuclear facilities and sites with sources of ionizing radiation [4]. Event analysis system and the communication responsibilities should be described in a systematic manner in licensee documents.

8.2. The main objective of the defence in depth strategy is the timely detection and correction of factors that have led or could lead to deviations from the normal operation and emergencies, prevention of their progression into accidents, and also reduce and mitigate the consequences of accidents.

8.3. Plants should develop and apply effective system of reporting, collecting, recording, timely notification and presentation to the competent authorities of required information, screening (filtration), analysis, trending, use and distribution of own and external operating experience. Data accumulated in the databases should be accessible to anyone in the NPP. Activities in the field of operational experience should be systematically described in appropriate procedures.

8.4. Deviations from the normal operation should be thoroughly analyzed by competent experts, root causes for their occurrence should be identified and corrective measures to prevent them in the future should be developed and implemented.

8.5. Plants should disseminate relevant information to similar nuclear power plants, the manufacturers of the defective equipment, as well as to international organizations dealing with safety. Plants should have full membership in organizations for dissemination of operating experience and should timely send and receive such information, which could be useful in prevention of operational disturbances.

8.6. Plants should maintain regular contacts and exchange information on problematic issues with the designer and the manufacturers of equipment, especially when advice is needed or equipment is replaced. Important are relationships with the so called support organizations (research institutes, design organizations and outside contractors) for analysis and resolution of issues.

8.7. Within the framework of exchange of operating experience, information on "Good practices" should be exchanged in respect of: safety improvement activities; improving operating procedures; prevention of violations during operations; information on methods, tools and data for the assessment of SSC lifetime. Operational experience feedback system should provide for documentation of assessments in respect of applicability of external experience. Periodically, these assessments should be reported and discussed at the Safety Councils and should be made available to the NPP management.

8.8. Events with safety consequences should be analyzed by both the actual and the potential impact. Safety significant events should be analyzed for identification of direct and root causes related to: SSC design, operation, maintenance, human and organizational factors. Analysis results, as appropriate, should be included in staff training programs. Where necessary, amendments should be made to the documents related to the event.

8.9. Plants should use internationally recognized event analysis methodologies or combinations of such methodologies.

8.10. Events analysis methodologies assist people to clarify what, when, how and why it happened (facts, conditions and circumstances, direct, contributing and root causes). Analysts should not determine guilt (who is to blame) [4]. The analysis of event causes should be described in separate documents (reports), which justify the logical sequence and reasons contributing to the event outcome (unavailability or failure of SSCs; forced outage or repetition of operations). These may be weaknesses in the training programs, deficiencies, lack of or violation of procedures, safety culture issues.

8.11. In any case, cause analysis should clearly identify the role of human and organizational factors and the potential safety consequences.

8.12. Beneficial for the safe operation is the creation of an atmosphere and opportunities to freely and openly (without fear of punishment) report and record own and others mistakes related to organization and implementation of activities.

8.13. Beneficial for the safety of NPPs is the practice of registration and analyses of so called "Low level" events - those are daily defects, weaknesses and findings, which have no safety significance and consequences. Trend of recurrence and increase in number of such abnormalities of the same type is a clear indication that there is a common direct cause, which could be eliminated before it propagates as an initiating event or as a contributing cause for a significant event. In this category more weight have "near-misses" events that could lead to a significant event, but did not by favourable coincidences.

8.14. Particular attention should be paid to the analyses of precursors, which are associated with impact on one or more safety functions or safety systems, whether or not they have lead to a real impact on the normal operation. The analysis should consider all possible initiating events, associated with the respective function or safety system. From the available scenarios and event sequences (event trees, fault trees), the predecessor event scenario should be selected for in depth analyses.

8.15. Good practices in analysis of events with impact on the safety functions include the application of probabilistic analysis to assess the consequences (core damage) [18].

8.16. The information collected in the deviations and failures database should be reviewed, analyzed, screened for adverse safety trends by competent experts. Analysis system should ensure that lessons learnt (in different sectors) reach the appropriate officials with the authority to take decisions and actions, before deviations develop into incidents and accidents.

8.17. On the basis of the analysis of incidents and accidents and the lessons learnt, adequate and timely corrective actions should be taken by responsible persons to prevent recurrence. Priority should be given to planning and implementation of corrective measures to restore the affected safety functions. In determining corrective measures, it should be clarified whether: problems are permanently or temporarily solved; implementation time is realistic; compatibility with and experience from other measures is ensured. Corrective measures should be conservative to a reasonable extent.

8.18. Formal system should monitor implementation and reporting progress, as well as should evaluate effectiveness. The operating personnel should be adequately familiar with the analysis of events and the corrective measures taken to prevent recurrence.

8.19. In its safety culture policy, plant management should educate and encourage personnel to document any deviation from normal operation, including those of low level or near-misses and events that may lead to SSC failures, such as human performance issues, procedure weaknesses or documentation deficiencies that may affect plant safety.

8.20. Plants should periodically review the effectiveness of the operating experience feedback system and the procedures and if necessary to modify them.

9. GLOSSARY

Initial operation of a SSC element - this is the time of commissioning and pre-operational adjustments of the plant, where the element concerned has experienced forced, thermal, corrosion or radiation impact. If a pressure vessel has passed pressure hydraulic or pneumatic tests at the manufacturing factory, for initial operation should be considered these tests [3].

Testing – obtained by experiments or identified by the use of models quantitative or qualitative features of the functioning of the system or component, to demonstrate compliance with design requirements.

Functional testing – following maintenance, outage or reconstruction to verify the conformity of actual performance with the design requirements and the instructions.

Checks – implementation of an operating procedure on a regular bases, to verify system performance and operability (usually at a reduced scope compared to the test).

Control of conditions - periodic checks, inspections, measurements and trend analysis to define current conditions or identify potential failure.

Verification - to carry out operational control of the performance or conditions and specification of faults.

Control a) assess compliance by observations or judgement, where needed accompanied by measurements, testing or calibration, and b) the process of formation or acquisition, transmission and presentation, comparison of signals from the process or the status of the SSC of controllers or staff .

Inspection - testing, measurement and review of SSCs, operational activities, processes, procedures and competence.

10. REFERRENCES

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