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Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants

DRAFT SPECIFIC SAFETY GUIDE DS485

(Revision of NS-G-2.12)

IAEA
INTERNATIONAL ATOMIC ENERGY AGENCY

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This Safety Guide was prepared under the IAEA's programme for safety standards. The requirements for the design, commissioning and operation of nuclear power plants are established in Safety Requirements publications on Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1 (Rev. 1) [1] and on Safety of Nuclear Power Plants: Commissioning and Operation, IAEA Safety Standards Series No. SSR-2/2 (Rev. 1) [2]. The requirements for safety assessment are established in Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4 (Rev. 1) [3]. The Safety Requirements publication on Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GSR Part 1 (Rev. 1) [4] addresses regulatory aspects throughout the operation of facilities and throughout the duration of associated activities and for any subsequent period of institutional control until there is no significant residual radiation hazard.

1.2. Ageing management for nuclear power plants is implemented to ensure that the effects of ageing will not prevent systems, structures, and components (SSCs) from being able to accomplish their required safety functions throughout the lifetime of the nuclear power plant (including its decommissioning) and it takes account of changes that occur with time and use [1]. This requires addressing both the physical ageing effects of SSCs, resulting in degradation of their performance characteristics, and the non-physical ageing (obsolescence) of SSCs, i.e. their becoming out of date in comparison with current knowledge, codes, standards and regulations, and technology.

1.3. Ageing management is most effective when it is properly carried out at all stages of the lifetime of a nuclear power plant.

1.4. Effective ageing management of SSCs is a key element of the safe and reliable operation of nuclear power plants. In order to assist its Member States in managing ageing effectively, the IAEA has developed a programme on International Generic Ageing Lessons Learned (IGALL) [5, 6]. In addition, the safety of nuclear power plants during long term operation has become more important owing to the steady increase in the number of operating organizations giving high priority to continuing the operation of nuclear power plants beyond the timeframe originally anticipated for their operation.

1.5. This Safety Guide supplements and provides recommendations on meeting the requirements relating to ageing management and long term operation that are established in SSR-2/1 (Rev.1) [1] and SSR-2/2 (Rev.1) [2]. It identifies key elements of effective ageing management for nuclear power plants.

1.6. This publication revises and supersedes the Safety Guide on Ageing Management for Nuclear

Power Plants issued in 2009. [1] This revision takes into account developments in the ageing management of nuclear power plants worldwide and expands the scope to include provisions for maintaining the safety of nuclear power plants during long term operation.

1.7. Periodic Safety Review for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-25 [7] also provides recommendations on some aspects of physical ageing of SSCs but focuses more on non-physical ageing of SSCs, i.e. their becoming out of date in comparison with current knowledge, codes, standards and regulations, and technology. It also stresses the need to seek safety improvements and implement those improvements that are practicable if the plant is to continue to operate beyond the timeframe originally anticipated for its operation.

OBJECTIVE

1.8. The objective of this Safety Guide is to provide recommendations for meeting Requirement 30: Qualification of items important to safety and Requirement 31: Ageing management of SSR-2/1 (Rev. 1) [1] and Requirement 14: Ageing management and Requirement 16: Programme for long term operation of SSR-2/2 (Rev. 1) [2].

1.9. This Safety Guide provides guidance for operating organizations on implementing and improving ageing management and on developing a programme for safe long term operation for nuclear power plants, which, among other aspects, takes due account of ageing management.

1.10. The Safety Guide may also be used by the regulatory body in preparing regulatory requirements, codes and standards, and in verifying effective ageing management in nuclear power plants.

SCOPE

1.11. The recommendations provided in this Safety Guide are applicable for nuclear power plants throughout their entire lifetime (including their decommissioning), taking into account the different reactor designs existing worldwide.

1.12. This Safety Guide focuses mainly on managing the physical ageing of SSCs within the scope of ageing management (‘in-scope SSCs’). It also provides recommendations on safety aspects of managing technological obsolescence and recommendations on the programme for safe long term operation of nuclear power plants for its ageing management related activities.

1.13. Other aspects relating to safe long term operation, such as obsolescence of knowledge (knowledge management and human resources) and compliance with current codes, standards and regulations, as well as plant design, the environmental impact of long term operation, economic

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.12, IAEA, Vienna (2009).

assessment and long term investment strategies, are outside of the scope of this Safety Guide. They are addressed in other IAEA safety standards, e.g. Refs [1, 7, 8]. Economic assessment for long term operation is covered in publications in the IAEA Nuclear Energy Series.

1.14. The recommendations in this Safety Guide also apply to facilities for spent fuel storage and radioactive waste management that are part of the nuclear power plant. The recommendations in this Safety Guide may also be used as a basis for ageing management at separate facilities for storage of spent nuclear fuel and for radioactive waste management. In this context, the recommendations provided in Storage of Spent Nuclear Fuel, IAEA Safety Standards Series No. SSG-15 [9] should be followed.

STRUCTURE

1.15. Section 2 presents basic concepts of managing ageing and obsolescence as well as their implications for a programme for safe long term operation, which provide a common basis for the recommendations provided in Sections 3, 4, 5, 6 and 7. Section 3 provides recommendations for ageing management of SSCs at each separate stage in the lifetime of a nuclear power plant. Section 4 provides recommendations on plant documentation and programmes relevant to ageing management and safe long term operation. Section 5 provides recommendations for managing ageing that are applicable throughout the entire lifetime of the nuclear power plant. Section 6 provides recommendations on the management of technological obsolescence in the operation stage. Section 7 provides recommendations on ageing related activities important for the safe long term operation of the nuclear power plant.

2. BASIC CONCEPTS

2.1. This section presents the basic concepts of ageing management, including their application to long term operation, which provide a common basis for the recommendations given in Sections 3, 4, 5, 6 and 7 of this Safety Guide.

2.2. Physical ageing is a general process in which physical characteristics of SSCs gradually deteriorate with time or use. It occurs due to physical degradation or chemical or biological processes (i.e. degradation mechanisms).

2.3. Non-physical ageing of SSCs is the process of their becoming out of date (i.e. obsolete) owing to the availability and evolution of knowledge and technology, and the associated changes in requirements, codes and standards.

2.4. Physical ageing is referred to in this Safety Guide as ageing while non-physical ageing is referred to in this Safety Guide as obsolescence.

2.5. Evaluation of the consequences of the cumulative effects of both ageing and obsolescence on

the safety of a nuclear power plant is a continual process and is required to be assessed in a periodic safety review or an equivalent safety assessment under alternative arrangements (see paras 4.6-4.8) [2, 7].

AGEING MANAGEMENT

2.6. Effective ageing management throughout the lifetime of SSCs requires the use of a systematic approach to managing the effects of ageing that provides a framework for coordinating all activities relating to the understanding, prevention, detection, monitoring and mitigation of ageing effects on the plant's structures and components. This approach is illustrated in Fig. 1, which is an adaptation of Deming's 'PLAN–DO–CHECK–ACT' cycle to the ageing management of SSCs.

2.7. Understanding the ageing of SSCs, as illustrated in Fig. 1, is the key to effective ageing management. This understanding is derived from the knowledge of:

- The current licensing basis[2] and anticipated updates to the licensing basis, where relevant (including regulatory requirements, codes and standards);
- Safety functions and other intended functions of the SSC;
- The design and fabrication processes used (including the material, the material properties, adverse residual effects from fabrication methods such as cold work or residual stresses in welds, specific service conditions, results from inspection or examination and testing in manufacturing);
- Equipment qualification (where applicable);
- The environmental characteristics for the SSCs during any delayed construction period, as these may affect the ageing performance of the SSCs;
- The environmental characteristics for the SSCs during operation and shutdown conditions, including, at a minimum, temperatures, humidity levels, aqueous parameters (e.g. water quality, levels of deleterious constituents) and neutron or gamma radiation fields;
- The operation, irradiation and maintenance history of SSCs, including their commissioning, repair, modification and surveillance histories;
- Operating experience at the plant or at other nuclear power plants;
- Relevant research results;
- Data and data trends from condition monitoring, inspection and maintenance.

2.8. To maintain plant safety the effects of ageing on SSCs (i.e. net changes in characteristics) should be detected in a timely manner, so as to be able to take appropriate actions to ensure that the

[2] The current licensing basis is the set of regulatory requirements applicable to a specific plant, the operating organization's commitments to ensuring compliance with and operation within applicable regulatory requirements and the plant specific design basis (including all modifications and additions to such commitments over the life of the licence). The current licensing basis also includes the plant specific design basis information as documented in a safety analysis report (which typically includes time limited ageing analyses), reports of periodic safety reviews and other plant documents.

required safety functions of SSCs are fulfilled over the entire lifetime of the nuclear power plant.

2.9. The PLAN activity in Fig. 1 involves coordinating, integrating and modifying existing programmes and activities that are related to managing the ageing of SSCs, and developing new programmes, if necessary.

2.10. Ageing management consists of design, operations and maintenance actions to prevent or to control, within acceptable limits, the ageing of SSCs. Ageing management is an interdisciplinary activity that involves engineering, maintenance, surveillance, equipment qualification, in-service inspection, safety analysis and other relevant plant programmes. Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.6 [10] provides guidance on maintenance, surveillance and inspection practices.

2.11. Ageing management covers all activities that aim to prevent or control ageing effects within acceptable limits through the entire lifetime of the nuclear power plant, i.e. in design, fabrication or construction, commissioning, operation including long term operation and decommissioning, including long term shutdown, as described in Section 3.

2.12. The ageing of SSCs increases the probability of common cause failures, i.e. the degradation of two or more physical barriers or redundant structures and components, which could result in the impairment of one or more levels of protection provided by the defence in depth concept. Therefore, in setting the scope of ageing management for structures and components, no credit should be taken for redundancy or diversity among SSCs.

2.13. Ageing management programmes should be developed using a structured methodology, to ensure a consistent approach in implementing ageing management, as described in Section 5.

2.14. Existing plant programmes, including those for maintenance, equipment qualification, in-service inspection, surveillance, and water chemistry, that can be credited where appropriate to manage ageing, ageing effects and degradation mechanisms are described in Section 4.

2.15. Where the existing plant programmes are not sufficient, those plant programmes should be improved or new ageing management programmes should be developed and implemented, as described in Section 5.

2.16. In practice, ageing effects and degradation mechanisms are studied and managed at the level of the structure or component. However, the ageing management programmes for individual structures or components may be integrated into an ageing management programme at the system and/or plant level.

2.17. The DO activity in Fig. 1 involves preventing and mitigating expected ageing effects and degradation mechanisms of SSCs by developing a specific operational procedure, a water chemistry programme or another chemistry or environmental control programme or/and by means of other preventive and mitigatory actions.

2.18. Effective ageing management is in practice accomplished by coordinating existing plant programmes and processes (or elements thereof that are relevant to ageing), and external activities such as research and development, as well as by implementing, coordinating or taking credit for other specific actions as described in Section 5.

2.19. The CHECK activity in Fig. 1 involves the timely detection and characterization of significant ageing effects and degradation mechanisms through the inspection and monitoring of structures and components and the assessment of observed ageing effects to determine the type and timing of any corrective actions required.

2.20. The ACT activity in Fig. 1 involves the timely correction of ageing effects on structures and components and the introduction of further preventive or mitigatory actions through appropriate maintenance and design modifications, including the repair and replacement of structures and components.

2.21. The closed loop of Fig. 1 indicates the continuation and improvement of ageing management, on the basis of feedback of relevant operating experience, results from research and development and results of self-assessment and peer reviews, to help ensure that emerging ageing issues will be addressed.

2.22. Time limited ageing analyses (also termed safety analyses that use time limited assumptions) should be applied, in certain cases, to demonstrate that the analysed ageing effects will not adversely affect the ability of the structure or component to perform its intended function throughout an assumed period of operation, as described in Section 5.

2.23. Time limited ageing analyses involve two types of parameters. The first parameter is the time dependent variable that is used in the analysis. Examples of this parameter are the neutron fluence, the operating time or the number of thermal cycles experienced by a structure or component. The second parameter evaluated is the ageing effect associated with the first parameter, which could be the neutron embrittlement of vessel material, the thermal embrittlement of cast austenitic stainless steel or the cumulative fatigue usage factor, respectively. Both parameters should be evaluated and compared with a regulatory limit or criterion to determine the acceptability of the structure or component for continued service.

2.24. The effectiveness of ageing management should be periodically reviewed to maintain plant safety and to ensure feedback and continuous improvement as described in Section 5.

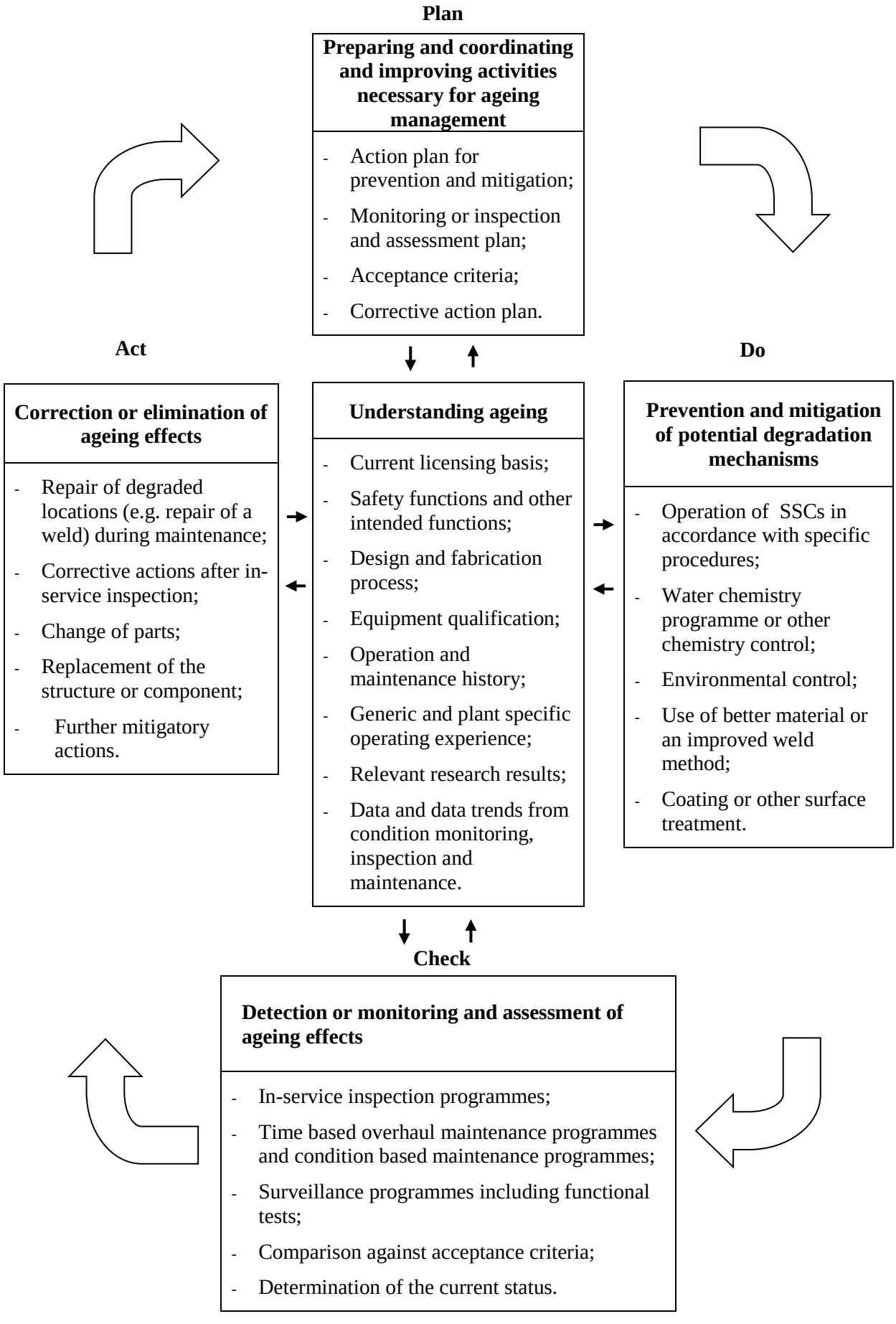

FIG.1. Systematic approach to ageing management

MANAGEMENT OF OBSOLESCENCE

2.25. Nuclear power plant safety can be impaired if the obsolescence of SSCs is not identified in advance and corrective actions are not taken before the associated decrease in the reliability or availability of SSCs occurs.

2.26. Management of obsolescence is a part of the general approach for enhancing nuclear power plant safety through ongoing improvements in both the performance of SSCs and safety management.

2.27. There are several types of obsolescence. The subject, manifestation, consequences and management approaches for three types of obsolescence are shown in Table 1.

2.28. Recommendations on the management of obsolescence of technology (also called technological obsolescence) are provided in Section 6.

2.29. Conceptual aspects of obsolescence, such as obsolescence of knowledge and compliance with current regulations, codes and standards, are addressed in Requirements 5 and 12 of SSR-2/2 (Rev. 1) [2], which deal with safety policy and periodic safety review and safety factors 2 and 8 of SSG-25 [7], which deal with actual conditions of SSCs important to safety and safety performance. Recommendations on these aspects are not provided in this Safety Guide.

TABLE 1. TYPES OF OBSOLESCENCE

Subject of obsolescence	Manifestation	Consequences	Management
Technology	Lack of spare parts and technical support; Lack of suppliers; Lack of industrial capabilities.	Declining plant performance and safety owing to increasing failure rates and decreasing reliability.	Systematic identification of useful service life and anticipated obsolescence of SSCs; Provision of spare parts for planned service life and timely replacement of parts; Long term agreements with suppliers; Development of equivalent structures or components.
Regulations, codes and standards	Deviations from current regulations, codes and standards, for structures, components and software; Design weaknesses (e.g. in equipment qualification, separation, diversity or capabilities for severe accident management).	Plant safety level below current regulations, codes and standards (e.g. weaknesses in defence in depth or higher risk of core damage (frequency).	Systematic reassessment of the plant against current regulations, codes and standards (e.g. through periodic safety review) and appropriate upgrading, back fitting or modernization.
Knowledge	Knowledge of current regulations, codes and standards and technology relevant to SSCs not kept current.	Opportunities to enhance plant safety missed.	Continuous updating of knowledge and improvement of its application.

PROGRAMME FOR LONG TERM OPERATION

2.30. Long term operation of a nuclear power plant is operation beyond an established time frame defined by the licence term, the original plant design, relevant standards or national regulations. Long term operation should be justified by safety assessment and, depending on the State, this justification may take place within a broader regulatory process such as licence renewal or a periodic safety review [7]. Among the various topics covered by the safety assessment, specific consideration should be given to adequate management of the ageing processes that can affect the SSCs within the scope of the evaluation for long term operation, and ensuring that those SSCs will retain their ability to perform their intended safety functions throughout the planned period of long term operation.

2.31. The plant's programme for long term operation is a set of activities, including evaluations, assessments, maintenance, inspections and testing, aimed at justifying and demonstrating plant safety for the planned period of long term operation. The programme for long term operation should be based on national regulatory requirements, should consider international best practices, operating experience and research findings, and should include an implementation plan, as described in Section 7.

2.32. If a decision is taken to pursue long term operation, justification of the adequacy of ageing management for the planned period of long term operation should be provided, based on the results of periodic safety reviews [7] or the results of an adequate evaluation process (that includes scope setting, ageing management review and revalidation of time limited ageing analyses, as described in this Safety Guide), and this justification should be evaluated for adequacy by the regulatory body.

3. AGEING MANAGEMENT THROUGHOUT THE LIFETIME OF THE NUCLEAR POWER PLANT

3.1. Ageing of in-scope SSCs (see paras 5.14 to 5.21) should be managed with foresight and anticipation through the entire lifetime of the plant, i.e. in design, construction, commissioning, operation (including long term operation and suspended operation) and decommissioning (e.g. with consideration given to the associated techniques, costs and exposure of workers). Management of ageing effects should be considered during all associated activities, such as engineering, procurement, fabrication, transport and installation.

3.2. Regulatory requirements for ageing management should be established and guidance should be developed to ensure that the operating organization of the nuclear power plant implements effective ageing management at each stage of the lifetime of the nuclear power plant.

3.3. Requirements on the use of operating experience and results from research and development are established in Requirement 6 of SSR-2/1 (Rev. 1) [1] and Requirement 24 of SSR-2/1 (Rev. 2) [2] and in GSR Part 4 (Rev. 1) [3]. Specifically for ageing management and long term operation, such activities should focus on:

- Ensuring that all levels of the analysis are either performed, or are specified and accepted, by qualified experts within the operating organization, to ensure that specific aspects relating to ageing management and long term operation are taken into account;
- Improvement of the understanding of ageing effects for all in-scope SSCs by analysis of operating experience from the nuclear power plant, from other nuclear power plants as well as from other industries when relevant, and results from research and development;
- Application of lessons identified in order to update and improve the ageing management.

3.4. The operating organization, in cooperation with the design organization and equipment suppliers, should ensure that proactive strategies for ageing management are established, especially

at the stages of design, construction and commissioning. Such strategies should take into account the latest knowledge of ageing effects and degradation mechanisms. Reference [11] provides more detailed information on proactive ageing management strategies for nuclear power plants.

3.5. The roles of all organizations that participate in ageing management of SSCs at different stages and in different activities should be properly defined and coordinated.

3.6. Ageing management activities should be overseen by the regulatory body throughout the lifetime of the nuclear power plant.

DESIGN

3.7. At the plant design stage and for licensing review, it should be demonstrated that ageing has been adequately taken into account.

3.8. Appropriate measures should be taken, such as the introduction of specific features in the design stage to facilitate effective ageing management throughout the operation stage of the plant. Such measures should also be applied to modifications and to the replacement of structures or components. Requirements 30 and 31 of SSR-2/1 (Rev. 1) [1] establish the design related requirements on ageing management of SSCs important to safety.

3.9. In the design stage, the following should be ensured:

- The operational states and accident conditions for the plant are taken into account in the equipment qualification programme
- The environmental conditions in operational states and accident conditions are taken into account in the design.
- All potential ageing effects and degradation mechanisms for SSCs that will perform passive and active functions are identified, evaluated and taken into account in the design. Examples of ageing effects and degradation mechanisms are provided in Ref. [5].
- Relevant experience (including experience from construction, commissioning, operation and decommissioning of nuclear power plants) and research results are reviewed and taken into account in the design.
- Appropriate materials with adequate ageing resistant properties are used.
- Materials testing programmes are in place for periodic monitoring of ageing effects during operation of the plant, taking into account the need for accessibility of the structures and components.
- Provisions for on-line monitoring are in place, particularly where this would provide forewarning of degradation leading to failure of SSCs and where the consequences of failure could be important to safety.
- Relevant actions are taken to make inspections and maintenance possible for SSCs over the lifetime of the nuclear power plant.
- Provisions for relevant preventive and/or mitigatory measures (e.g. appropriate chemistry

programmes) are considered.

3.10. In the design and procurement documents for a new nuclear power plant or new SSCs, the operating organization should specify requirements that facilitate ageing management, including specification of information to be included in documentation from vendors, contractors, suppliers and manufacturers.

3.11. Ageing management should be addressed in the safety analysis report and other licensing documents. The description of ageing management in the safety analysis report should include general information on the following topics [12]:

- The strategy for ageing management and prerequisites for its implementation;
- Identification of all SSCs of the plant that could be affected by ageing and are in the scope of the ageing management;
- Proposals for appropriate materials monitoring and sampling programmes in cases where it is found that ageing effects may occur that may affect the capability of SSCs to perform their intended function throughout the lifetime of the plant;
- Ageing management for different types of in-scope SSCs (e.g. concrete structures, mechanical components and equipment, electrical equipment and cables and instrumentation and control equipment and cables) and means to monitor their degradation;
- Design inputs for equipment qualification (see Section 4) of the in-scope SSCs, including required equipment, and equipment functions that need to be qualified for service conditions in normal operation and associated with postulated initiating events;
- General principles stating how the environment of an SSC is to be maintained within specified service conditions (e.g. by means of proper location of ventilation, insulation of hot SSCs, radiation shielding, damping of vibrations, avoiding submerged conditions and proper selection of cable routes);
- Appropriate consideration of the analysis of feedback of operating experience with respect to ageing.

3.12. The operating organization should establish a specific equipment qualification programme, including consideration of ageing of SSCs, that meets Requirement 30 of SSR-2/1 (Rev. 1) [1] and Requirement 13 of SSR-2/2 (Rev. 1) [2].

FABRICATION AND CONSTRUCTION

3.13. The operating organization should ensure that suppliers adequately address factors affecting ageing management and that sufficient information and data on fabrication are provided to the operating organization, so that the operating organization can take this information into account in developing ageing management programmes, including operating and maintenance procedures.

3.14. The operating organization should ensure that:

- Current knowledge about relevant potential ageing effects and degradation mechanisms as well as possible preventive and/or mitigatory measures are taken into account in the fabrication and construction of in-scope SSCs by manufacturers;
- The transport and storage conditions of manufactured equipment are appropriate to avoid premature ageing effects and/or conditions that can promote subsequent ageing;
- All relevant reference (baseline) data are collected and documented (e.g. information and data on material chemistry and material properties);
- Sufficient surveillance specimens for specific ageing monitoring programmes (to cover possible periods of long term operation) are made available and can be obtained in accordance with design specifications;
- Equipment qualification tests carried out by the manufacturer are in compliance with the applicable equipment qualification programme.

3.15. If a delayed construction period has occurred at the plant, the operating organization should identify and document the environmental conditions that could affect the physical condition of SSCs and their long term ageing behaviour, and should make any necessary modifications to the ageing management programme for the SSCs.

COMMISSIONING

3.16. The operating organization should establish a programme for measuring and recording baseline data relevant to ageing management for all in-scope SSCs. This programme should include mapping the actual environmental conditions in each critical location of the plant to ensure that they are in compliance with the design.

3.17. The operating organization should verify that the actual environmental conditions are consistent with those considered in the design of SSCs. Special attention should be paid to the identification of 'hot spots' in terms of temperature and levels of radiation, and to measurement of vibration levels. All parameters that can influence degradation mechanisms should be identified as early as possible, monitored if possible and tracked throughout the operation of the plant.

3.18. The operating organization should collect baseline data and should also confirm that critical service conditions (as used in equipment qualification) are in compliance with the design. Analyses of such data should be subject to review by the regulatory body.

3.19. The operating organization should ensure that SSCs are not subjected to unnecessary stresses by tests performed during commissioning that are not accounted for in the design or that could cause premature ageing. The operating organization should properly document the testing and record the test results during commissioning, in order to allow investigation of possible cases of subsequent premature ageing that may have been caused by improper execution of some testing.

OPERATION

3.20. A systematic approach (see Fig. 1) should be applied to manage ageing and obsolescence of SSCs, to ensure that required intended functions are maintained at all times during the operation stage of the lifetime of the nuclear power plant.

3.21. The operating organization should ensure that programmes and documentation relevant to the management of ageing (see Sections 4 and 5) and technological obsolescence (see Section 6) are implemented during the operation stage. Where necessary, new programmes and documentation should be developed or existing programmes and documentation should be reviewed and modified to ensure that they will be effective for managing ageing.

3.22. The operating organization should ensure that specific operational procedures for the water chemistry programme or other environmental control programmes and other preventive or mitigatory actions with respect to ageing are followed.

3.23. Specific parameters of concern should be monitored and recorded during plant operations to demonstrate compliance with critical service conditions, operational limits and conditions, and any other parameters that were identified as affecting ageing assumptions used in safety analyses or equipment qualification.

3.24. The operating organization should ensure the timely detection and characterization of significant ageing effects through the inspection and monitoring of in-scope structures or components, and the assessment of observed ageing effects to determine the type and timing of any actions required.

3.25. The operating organization, in cooperation with design organizations, should ensure that corrective actions are followed or taken to prevent or mitigate ageing effects of structures or components through the appropriate maintenance, repair and replacement or modification of a structure or component, and/or through appropriate changes to relevant plant operations, programmes and documentation.

3.26. In the event of operational changes or modifications to SSCs, the operating organization should ensure that a review is performed of possible changes in environmental or process conditions (e.g. temperature, flow pattern, velocity, vibration, radiation, hot spots) that could affect ageing or lead to the failure of SSCs. If necessary, an ageing management review should be completed for the affected SSCs.

3.27. The availability of spare parts or replacement parts and the shelf life of spare parts or consumables should be continuously monitored and controlled (see Section 6).

3.28. Where spare parts or consumables could be vulnerable to degradation mechanisms owing to their storage environment (e.g. high or low temperatures, moisture, chemical attack, dust accumulation), measures should be taken to ensure that they are stored in an appropriately controlled environment.

3.29. For major SSCs important to safety, the operating organization should consider preparing contingency plans or exceptional maintenance plans to deal with their potential ageing effects or their failure caused by potential ageing effects and degradation mechanisms.

3.30. Evaluation of relevant operating experience and research and development programmes should be continuously performed to support better understanding of degradation mechanisms and their ageing effects and to improve the ageing management programmes. If a new ageing effect or degradation mechanism is discovered (e.g. through feedback of operating experience or research and development), the operating organization should perform an appropriate ageing management review and should implement additional ageing management as necessary.

LONG TERM OPERATION

3.31. If long term operation is contemplated, the operating organization should establish policy documents, dedicated organizational structures and action plans to perform evaluations for long term operation well before the plant enters into long term operation. The operating organization should specify subjects for evaluation for long term operation and should assess the current physical status of relevant SSCs during the preparation phase for long term operation (see Section 7).

3.32. The operating organization should justify that the physical status of structures or components will be managed consistent with the current licensing basis for the planned period of long term operation.

3.33. Concerning ageing management, the operating organization should review and validate the existing programmes and processes (or elements thereof) relevant to ageing for all in-scope structures or components.

3.34. For in-scope structures or components, the operating organization should identify all time limited ageing analyses and should demonstrate either that all these analyses will remain valid for the planned period of long term operation, or that the structures or components will be replaced, or that further operation maintenance or ageing management actions will be implemented.

3.35. Since long term operation is operation beyond the originally established timeframe and evaluations for long term operation are based on assumptions, the operating organization should periodically perform the following activities to validate or correct the ageing related assumptions so that plant safety during long term operation is ensured and improved:

- Evaluation of operating experience at the plant or at other nuclear power plants after entering long term operation;
- Analysis of trends in ageing effects;
- Review of the effectiveness of the ageing management programmes and existing plant programmes for long term operation;
- Incorporation of relevant research and development results;

– Evaluation of the need for new research and development.

3.36. Decisions concerning ageing management and long term operation should take due account of the potential implications for the subsequent decommissioning stage.

SUSPENDED OPERATION

3.37. Suspended operation is plant shutdown lasting for a period exceeding generally more than one year, and which excludes regular outages for maintenance. During suspended operation, SSCs may need to be placed in temporary lay-up or safe-storage states that require supplementary measures and controls to minimize or prevent ageing effects.

3.38. The operating organization should review and, where necessary, revise the ageing management programmes to ensure that relevant factors affecting ageing are taken into account for SSCs placed in lay-up or safe-storage states during suspended operation.

3.39. Required provisions for ageing management should be defined in specifications or preservation plans for SSCs in lay-up, including requirements for any condition assessments to be completed prior to the return to service of the plant following a period of suspended operation.

3.40. The provisions for ageing management, including the scope of condition assessments, should be reassessed if the duration of the shutdown is greatly extended beyond what was originally anticipated (for example, owing to unforeseen issues or delays in the return to service).

DECOMMISSIONING

3.41. Between the permanent shutdown of operations at the reactor and implementation of the approved final decommissioning plan, there may be a period of transition. During this transition period appropriate ageing management arrangements should be put in place to ensure that required SSCs remain available and functional. This may necessitate the implementation of relatively long term ageing management provisions for certain SSCs such as containment and spent fuel pool systems, fire protection systems, lifting equipment and monitoring equipment. Such provisions should be consistent with national regulations.

3.42. The operating organization should establish and implement ageing management activities in decommissioning plans and procedures for SSCs that are required to remain available and functional during decommissioning (e.g. ensuring the long term integrity of SSCs to prevent their deterioration and to allow the safe dismantling, handling and transport of components until the completion of decommissioning; monitoring of SSCs to ensure the integrity of the containment and to ensure that there are no significant radioactive releases during the transition period until completion of decommissioning; ensuring the integrity of subsurface infrastructure components; monitoring for the potential spread of contamination from previous releases, particularly the transport of radionuclides in groundwater; and conducting effective measures to minimize the

spread of contamination).

4. RELEVANT PLANT DOCUMENTATION AND PROGRAMMES

4.1 The following nuclear power plant programmes and documentation relevant to ageing management and, where relevant, evaluation for long term operation (also called 'preconditions for long term operation') should be in place at the plant:

- The safety analysis report and other current licensing basis documents;
- Configuration and modification management programmes, including design basis documentation;
- Plant programmes relevant to ageing management;
- Plant programmes relevant to long term operation;
- Time limited ageing analyses, in accordance with Section 5.

4.2 Each plant programme and analysis should be properly documented in safety analysis reports or in other current licensing basis documents, which should clearly and adequately describe the current licensing basis or the current design basis requirements for operation of the nuclear power plant.

SAFETY ANALYSIS REPORT AND OTHER CURRENT LICENSING BASIS DOCUMENTS

4.3 The policy on ageing management and the justification of long term operation should be properly documented in the current licensing basis, in particular in such documents as the safety analysis report, reports of periodic safety reviews (if applicable) or other licensing basis documents.

4.4 The safety analysis report should be kept updated to reflect the results of the ageing management review [12].

4.5 The safety analysis report or other licensing documents should provide descriptions of activities in support of safe long term operation to ensure that the operating organization maintains the necessary information to reflect the current status of the plant and addresses new issues as they arise.

4.6 A periodic safety review is a systematic, comprehensive assessment of the plant's safety [2]. The content and the scope of the periodic safety review should be consistent with the recommendations provided in SSG-25 [7]. Among the 14 safety factors described in SSG-25 [7], some have a strong link with ageing management. The operating organization should consider in particular:

- The adequacy of the design of the nuclear power plant (safety factor 1) and its documentation, by assessment against the current licensing basis and national and international standards,

requirements and practices.

- Thoroughly documenting the actual condition of each SSC important to safety (safety factor 2). Knowledge of any existing or anticipated obsolescence of plant systems and equipment should be considered part of this safety factor.
- Whether qualification of equipment important to safety (safety factor 3) is being maintained through an adequate programme that includes maintenance, inspection and testing and that provides assurance that safety functions will be maintained at least until the next periodic safety review.
- The effects of ageing on nuclear power plant safety, the effectiveness of ageing management programmes and the need for improvements to ageing management programmes, as well as the obsolescence of technology used in the nuclear power plant (safety factor 4).

4.7 If national requirements do not require periodic safety review, an alternative systematic comprehensive safety assessment that meets the objectives of the periodic safety review is recommended to be performed [7].

4.8 The assessment should also consider the safety performance indicators of the plant, plant specific operating experience, and operating experience from other nuclear power plants, and national and international research findings, which can reveal previously unknown weaknesses in safety.

CONFIGURATION AND MODIFICATION MANAGEMENT PROGRAMMES, INCLUDING DESIGN BASIS DOCUMENTATION

4.9 As the preparation of the plant for safe long term operation usually includes a number of important safety modifications and refurbishments, the plant should follow a configuration management programme or modification management programme [1, 2, 13] that reflects the evolving status of the plant.

4.10 All modifications of SSCs, releases of process software, operational limits and conditions, set-points, instructions and procedures should be properly documented and retained in an auditable and retrievable form. All safety significant modifications should be included within the safety analysis report [12, 13, 14].

4.11 For the purpose of a formal process to maintain design integrity, the plant should establish an organizational entity (e.g. a unit or member of staff) that has overall responsibility for the design process, that approves design changes and that is responsible for ensuring that the knowledge of the design basis is maintained [14].

4.12 The management system should contain the processes and activities relating to the configuration management programme and the modification management programme.

4.13 The design basis documentation, including design basis requirements and supporting design

basis information, should be owned by or accessible to the operating organization to support appropriate configuration management and modification management and to allow identification of the time limited ageing analyses for the plant.

4.14 The design basis information and any changes to it should be included in the safety analysis report or separate design basis documentation [13, 14].

4.15 If design basis documentation is not complete or is obsolete, an appropriate programme for reconstitution of the design basis should be implemented.

PLANT PROGRAMMES

4.16 The following existing plant programmes are essential to ageing management and evaluations for long term operation:

a) Maintenance programmes;
b) The equipment qualification programme;
c) In-service inspection programmes;
d) Surveillance programmes;
e) The water chemistry programme;
f) The corrective action programme.

4.17 Existing programmes that are credited for ageing management and used in evaluations for long term operation should be consistent with the nine attributes listed in Table 2.

4.18 Such existing programmes should be a part of the management system of the operating organization.

Maintenance programmes

4.19 Maintenance programmes that are consistent with NS-G-2.6 [10] should be in place and should be properly implemented for ageing management and evaluations for long term operation of applicable in-scope SSCs.

4.20 The maintenance programmes should clearly specify the links with the ageing management programmes, including the frequency of maintenance activities and specific information on the tasks and their evaluation and on the retention of records.

4.21 The plant maintenance programmes should be assessed to ensure that in-scope SSCs are capable of performing their intended functions throughout operation, including the planned period of long term operation.

4.22 The results of the assessments should be used to improve the existing maintenance programmes. The documentation of the assessments should cover all maintenance activities and should provide technical references to support findings and conclusions.

Equipment qualification programme

4.23 An equipment qualification programme to achieve and maintain the qualified status of in-scope SSCs should be in place in order to meet Requirement 30 of SSR-2/1 (Rev. 1) [1] and Requirement 13 of SSR-2/2 (Rev. 1) [2].

4.24 In this Safety Guide, 'environmental qualification' means the part of equipment qualification that focuses on qualification of equipment for temperature, pressure, humidity, contact with chemicals, radiation exposure, meteorological conditions, submergence and ageing mechanisms as conditions that could affect the proper functioning of the equipment.

4.25 Environmental qualification should demonstrate that, at the end of its qualified life, the equipment will still be capable of performing its intended function(s) under the full range of specified service conditions.

4.26 Environmental qualification should establish the qualified life of equipment within which ageing effects would not prevent satisfactory performance of the equipment if a postulated accident were to occur within the established operating period (possibly including long term operation).

4.27 Monitoring of actual environmental conditions should be implemented in order to get additional information necessary for the assessment of ageing effects on the equipment in its actual operating environment.

4.28 The qualified life of equipment should be reassessed during its lifetime, taking into account progress in the knowledge and understanding of degradation mechanisms and the actual operating environment of the equipment. If the qualified life is to be increased, a thorough safety demonstration should be provided by the operating organization.

4.29 The qualification status of equipment should be properly documented and maintained throughout the plant lifetime. The documentation relating to equipment qualification, which is typically part of the equipment qualification programme, should include:

a. A master list of qualified equipment;

b. Results of temperature monitoring and radiation monitoring in the plant;

c. The evaluation report for equipment qualification;

d. Test reports relating to equipment qualification;

e. Reports of time limited ageing analyses relating to equipment qualification (for evaluation for long term operation), or reports of another suitable equivalent analysis.

4.30 The review of equipment qualification should include an assessment of the effectiveness of the plant's equipment qualification programme in accordance with Requirement 13 of SSR-2/2 (Rev. 1) [2]. The review should also consider the effects of ageing on equipment during service and the effects

of possible changes in environmental conditions during normal operation and postulated accident conditions since the equipment qualification programme was implemented.

4.31 Details of recommended practices, processes and methods relating to equipment qualification are given in Ref. [15].

In- service inspection programmes

4.32 In-service inspection programmes that are consistent with NS-G-2.6 [10] should be in place and properly implemented for ageing management and evaluations for long term operation of applicable in-scope SSCs, including consideration of baseline data.

4.33 In-service inspection procedures should be effective in detecting degradation and it should be demonstrated that ageing effects will be adequately detected with the proposed inspection or monitoring technique.

4.34 The results of in-service inspection should be documented such that a trending analysis can be carried out using the results obtained from sequential inspections at the same location.

4.35 In-service inspection results that indicate notable degradation (e.g. if the degradation is greater than expected or if it approaches the acceptance criteria) should be evaluated to ensure that the extent of degradation at similar locations is appropriately determined. SSCs in redundant subsystems should be inspected independently to detect possible differences in their ageing behaviour.

4.36 A list or database should be developed and maintained to document the adequacy of non-destructive examination in detecting, characterizing and trending the degradation of structures or components. The database should provide the technical bases to support the findings and the conclusions necessary to support ageing management decisions.

Surveillance programmes

4.37 Surveillance programmes, including functional tests, that are consistent with NS-G-2.6 [10] should be in place and properly implemented for ageing management and evaluations for long term operation of applicable in-scope SSCs.

4.38 The surveillance programmes should confirm the provisions for safe operation that were considered in the design and assessed in construction and commissioning, and which are verified throughout operation.

4.39 The surveillance programmes should continue to supply data from monitoring relevant parameters to be used for assessing the service life of SSCs for the planned period of long term operation, for example through existing or additionally installed means for measuring temperature and pressure, or through additional diagnostic systems.

4.40 The surveillance programmes should verify that the safety margins for long term operation are adequate and provide a high tolerance for anticipated operational occurrences, errors and

malfunctions.

4.41 Particular attention should be paid to the following aspects:

- The integrity of the barriers between radioactive material and the environment (i.e. the primary pressure boundary and the containment);
- The availability of safety systems such as the reactor protection system, the safety system actuation systems and the safety system support features [16];
- The availability of items whose failure could adversely affect safety;
- Functional testing in accordance with Requirement 31 of SSR-2/2 (Rev. 1) [2] to ensure that the tested SSCs are capable of performing their intended function(s).

4.42 Surveillance programmes using representative material samples (such as material specimens for surveillance of the reactor pressure vessel, cable samples and corrosion coupons) should be reviewed and extended or supplemented for ageing within the period of long term operation, if necessary.

4.43 The documentation on the relevant initial conditions of the material samples used for surveillance should be identified, the adequacy of the information should be assessed, and the documentation should be supplemented as necessary.

4.44 Appropriate testing procedures and evaluation methods should be considered for defining the set of specimens to be included in the supplementary material surveillance programme for the reactor pressure vessel, if necessary, at least for alternative assessments such as the master curve approach for assessing fracture toughness.

Water chemistry programme

4.45 A water chemistry programme is essential for the safe operation of a nuclear power plant and should be in place [17]. The programme should ensure that degradation due to stressors in water chemistry does not impact the ability of SSCs to perform their intended functions, in accordance with the assumptions and the intent of the design. The water chemistry programme should avoid and/or minimize the harmful effects of chemical impurities and corrosion on plant SSCs.

4.46 The operating organization should ensure that the plant water chemistry programme is effective in maintaining the water quality required by the technical specifications.

4.47 The water chemistry programme should specify the scheduling and the analytical methods used to monitor chemistry (some programmes use automated on-line monitoring equipment, while others use wet chemical methods), and the means of verification of the effectiveness of the chemistry programme.

4.48 The water chemistry programme should also provide the necessary chemical and radiochemical environment to ensure safe long term operation and the integrity of structures or

components within the scope of ageing management and evaluations for long term operation.

Corrective action programme

4.49 A corrective action programme should be put in place to ensure that conditions adverse to quality, such as ageing related degradation, are identified and that corrective actions commensurate with the significance of the issue are specified and implemented.

4.50 The corrective action programme should document occurrences of identified ageing related degradation (conditions adverse to quality) and the methods used address the degradation, such as evaluation and acceptance, evaluation and monitoring, repair, or replacement. Such information should be taken into account as plant specific operating experience.

4.51 The corrective action programme should document the modifications to ageing management programmes, system configuration or plant operations that are made to manage the occurrence or the severity of the ageing effect.

4.52 The corrective action programme and the associated plant specific operating experience should be routinely reviewed by individuals responsible for the relevant ageing management programme. The review should determine whether ageing management programmes need to be enhanced to ensure that the corrective action programme is effective in managing the ageing effects for which it is credited.

4.53 If it is determined, through the evaluation of the corrective action programme and the associated plant specific operating experience, that the ageing management programmes do not adequately manage the effects of ageing, modifications to the existing ageing management programmes should be specified and implemented, or new ageing management programmes should be developed, as appropriate.

5. MANAGEMENT OF AGEING

ORGANIZATIONAL ARRANGEMENTS

5.1 For the implementation of the plant programme for ageing management, the policy and objectives of the programme should be established and the necessary resources (human resources, financial resources, tools and equipment, and external resources) should be identified and allocated. The organizational arrangements, such as the organizational structure and the policies of the operating organization should meet national requirements and IAEA safety standards [2, 8, 18, 19, 20], and should be in accordance with national practices,

5.2 Suitable organizational and functional arrangements should be established, such as those shown in Fig. 2, in which all necessary members of staff of the operating organization of the plant and of external organizations are involved and support ageing management.

5.3 An authorized organizational entity (e.g. an ageing management unit, manager or task force) should be assigned responsibilities for ageing management, as specified in para. 5.4. This ageing management entity should have close relationships with other organizational units within the plant, such as the operations, maintenance, engineering and management system units. Interdisciplinary ageing management teams consisting of members of different units of the plant and external experts may be established if necessary, on a permanent or ad hoc basis.

5.4 The responsibilities of the ageing management entity should include:

- Development of the plant's ageing management programme;
- Coordination of existing and new plant programmes that are relevant to ageing management;
- Systematic monitoring of relevant operating experience and research and development results, and evaluation of their applicability to the nuclear power plant;
- Direction of interdisciplinary ageing management teams for managing complex ageing issues;
- Assessment and optimization of ageing management programmes;
- Dealing with external technical support organizations;
- Evaluation of further training needs;
- Performance of periodic self-assessments;
- Improvement of activities relating to ageing management.

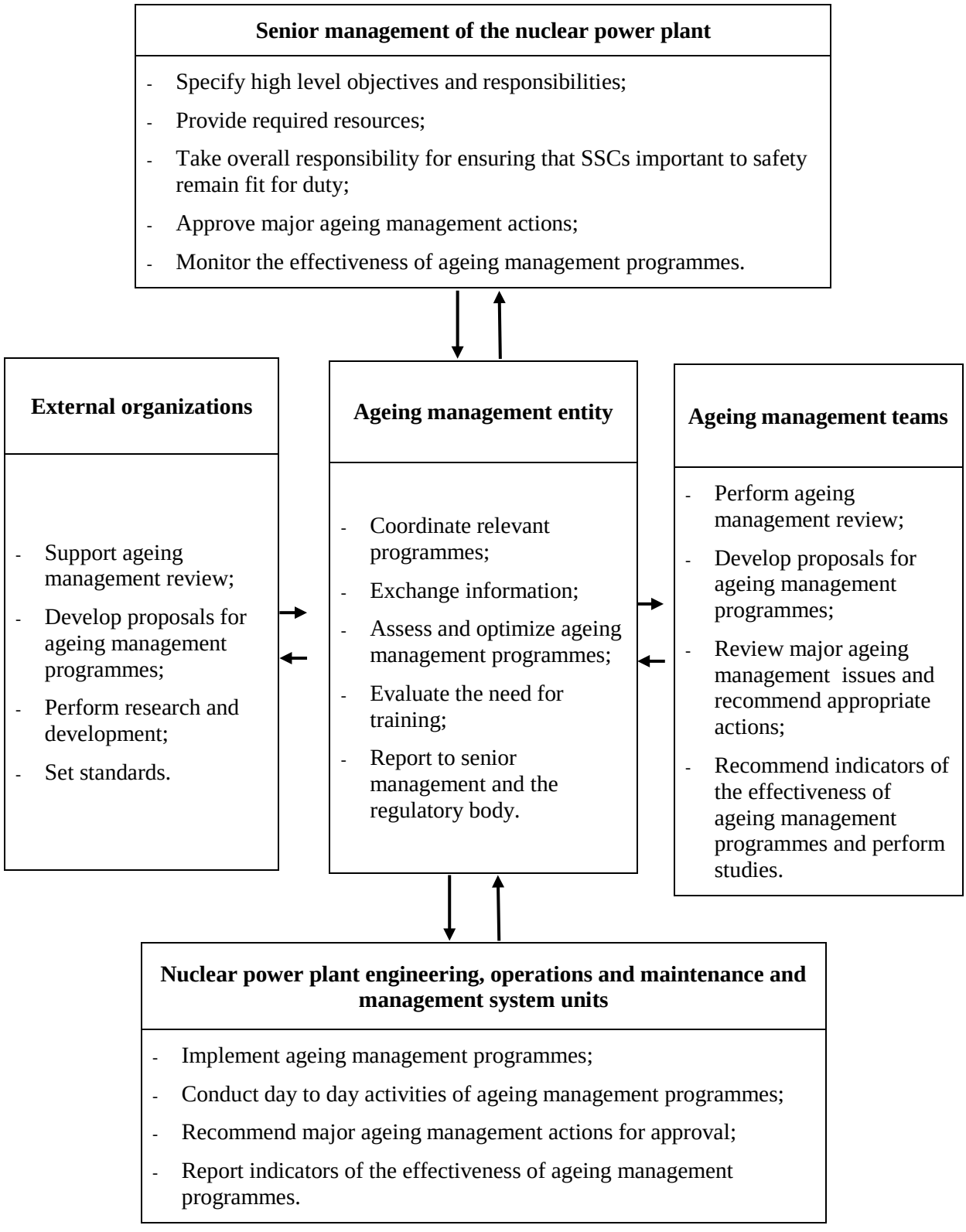

FIG. 2 Example of organizational arrangements in support of ageing management

5.5 Management of complex ageing issues may require an interdisciplinary approach. The members of the ageing management teams (see Fig. 2) should include experts from operations, maintenance, engineering, equipment qualification, design and research and development, depending on the evaluations necessary. If necessary, external organizations should be requested to provide expert services on specific topics, such as condition assessments, research and standards development.

5.6 Responsibilities for the implementation of ageing management programmes and for reporting on the performance of SSCs should be defined and allocated within the operating organization (e.g. the operations, maintenance and engineering units).

5.7 Training on the effects of ageing on SSCs should be provided for personnel involved in operations, maintenance and engineering, to enable them to make an informed and effective contribution to ageing management.

5.8 Relevant plant and industry operating experience should be systematically collected and evaluated and should be used for improving the ageing management programmes.

DATA COLLECTION AND RECORD KEEPING

5.9 A data collection and record keeping system should be in place as a necessary base for the support of ageing management. Examples of data that should be included in the data collection and record keeping system are described in Ref. [21].

5.10 The data collection and record keeping system should be established in the early stages of the lifetime of the plant (ideally, data should be collected from the construction stage onwards) in order to provide information for the following activities:

- Identification of fabrication, construction and environmental conditions that could adversely affect the ageing of SSCs, including any periods of delayed construction or suspended operation;
- Identification of relevant fabrication records, such as heat treatment history and certified reports on material tests;
- Identification and evaluation of degradation, failures and malfunctions of components caused by ageing effects;
- Decisions on the type and timing of maintenance actions, including calibration, repair, refurbishment and replacement;
- Optimization of operating conditions and practices that avoid or minimize ageing effects;
- Identification of all ageing effects before they jeopardize plant safety or reduce service lives of SSCs;
- Records of configuration and modification management, maintenance, surveillance and in-service inspection results and chemistry control records.

5.11 To facilitate obtaining the necessary quality and quantity of ageing related data from plant

operation, maintenance and engineering, representatives of the operations, maintenance and engineering units should be involved in the development and maintenance of the data collection and record keeping system.

5.12 Design documentation, including documentation from suppliers, should be made available as this is essential in supporting effective ageing management.

5.13 The use of available generic data should be considered until the plant has developed its own data from the construction stage onwards.

SCOPE SETTING FOR SYSTEMS, STRUCTURES AND COMPONENTS

Scope setting

5.14 A systematic scope setting ('scoping') process to identify SSCs subject to ageing management should be developed and implemented.

5.15 A list or database of all SSCs at the nuclear power plant (such as a master list of SSCs) should be made available before the scope setting process is commenced.

5.16 The following SSCs should be included in the scope of ageing management:

- SSCs important to safety that are necessary to fulfil the fundamental safety functions [1]:
  - (i) Control of reactivity;
  - (ii) Removal of heat from the reactor and from the fuel store;
  - (iii) Confinement of radioactive material, shielding against radiation and control of planned radioactive releases, as well as limitation of accidental radioactive releases.
- Other SSCs whose failure may prevent SSCs important to safety from fulfilling their intended functions. Examples of such potential failures are:
  - Missile impact from rotating machines;
  - Failures of lifting equipment;
  - Flooding;
  - High energy line break;
  - Leakage of liquids (e.g. from piping or other pressure boundary components).
- Other SSCs that are credited in the safety analyses (deterministic and probabilistic) as performing the function of coping with certain types of events, consistent with national regulatory requirements, such as:
  - SSCs needed to cope with internal events, e.g. internal fire and internal flooding;
  - SSCs needed to cope with external hazards, e.g. extreme weather conditions, earthquake, tsunami, external flooding, tornado and external fire;
  - SSCs needed to cope with specific regulated events, e.g. pressurized thermal shock,

anticipated transient without scram and station blackout;

- SSCs needed to cope with design extension conditions [1] or to mitigate the consequences of severe accidents.

5.17 Structures and components that satisfy both of the following conditions can be excluded from the scope of ageing management:

- Structures and components subject to periodic replacement or a scheduled refurbishment plan on the basis of predefined rules (based on a manufacture's recommendation or other basis and not on an assessment of the condition of the structure or component, which would comprise implementation of ageing management for the structure or component); and
- Structures and components that are not required by national regulatory requirements to be included in the scope.

5.18 If an SSC within the scope is directly connected to an SSC out of the scope, clear definitions of the boundaries between them should be established.

5.19 In addition, plant walk-downs should be used to check the completeness of the list of SSCs whose failure may prevent SSCs important to safety from performing their intended functions.

5.20 Since the subsequent process is carried out at the level of a structure or component (or its subcomponent), all structures or components and their subcomponents within the scope for ageing management should be identified. If the components or structures within a group have similar functions and similar materials and are in a similar environment, that group may be defined as a structure or component 'commodity group'.

5.21 After the scope setting process, a clear distinction between SSCs within the scope and those out of the scope should be evident. A typical scope setting process is illustrated in Fig. 3.

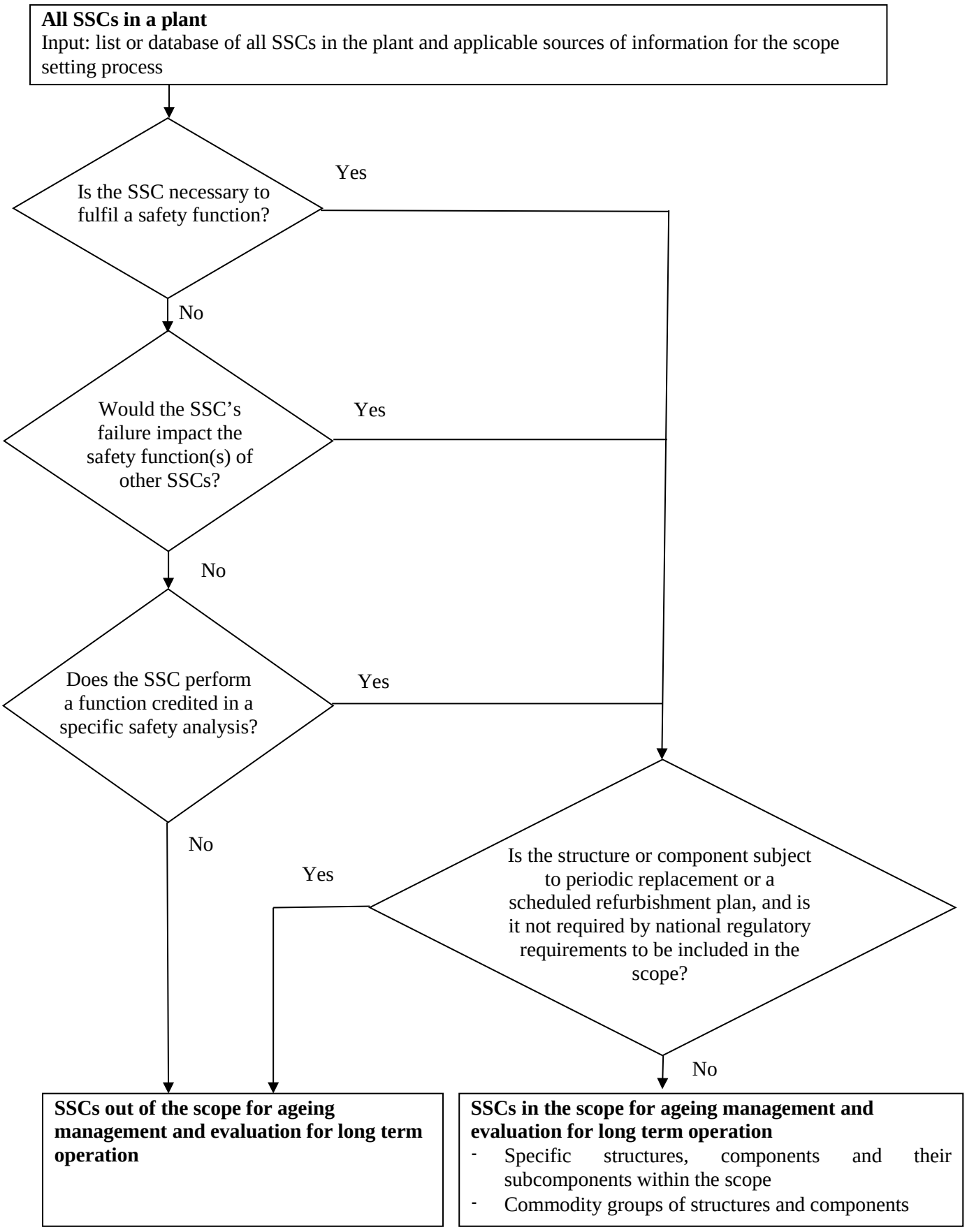

FIG. 3. Typical scope setting process for ageing management

5.22 An ageing management review for in-scope SSCs should be performed in order to ensure and demonstrate that ageing will be effectively managed.

5.23 The ageing management review should systematically assess ageing effects and their related degradation mechanisms that have been experienced or are anticipated. The assessment should include an evaluation of the impact of the ageing effect on the in-scope SSC's ability to perform their intended function(s) as specified in para. 5.16, including consideration of the current condition of the SSC.

5.24 Relevant applicable lessons relating to ageing [5] provide a good reference basis for the ageing management review but should not be used in place of a plant specific ageing management review.

Process to identify programmes to manage ageing of in-scope structures or components

5.25 A process to identify relevant ageing effects and degradation mechanisms for each structure or component should be established, and the programmes to manage the identified degradation mechanisms should be in place, as illustrated in Fig. 4. This process should cover the following steps:

1. Time limited ageing analyses associated with these structures or components should be evaluated to determine the continued validity of the analyses for the intended period of operation. Results of the evaluation of time limited ageing analyses should be taken into account in the ageing management review;
2. All relevant ageing effects and degradation mechanisms should be identified;
3. If the ageing of structures or components is managed by existing ageing management programmes, it should be verified that the ageing management programmes are consistent with the nine attributes shown in Table 2;
4. If the ageing of structures or components is managed by other plant programmes, such as maintenance, it should be verified that these programmes are consistent with the nine attributes shown in Table 2;
5. If the ageing of structures or components is not managed by any existing programme, a new programme should be established or existing programmes should be modified or improved, for example by extending the scope of an ageing management programme, or a specific action (e.g. replacement of the structure or component or further analysis) should be taken;
6. If the qualified lifetime of equipment important to safety expires, such equipment should be requalified or replaced at the expiration of its present qualification.

5.26 An ageing management review should be performed for each in-scope structure or component or commodity group of structures or components, and should consist of the following essential elements:

1. Assessment of the current condition of the structure or component;

2. Identification of ageing effects and degradation mechanisms based on fundamental knowledge for understanding ageing (such as the design basis, materials, the environment and stressors; see the box ‘understanding ageing’ in Fig. 1);
3. Identification of the appropriate programme for ageing management;
4. Reporting of the ageing management review to demonstrate that the ageing effects and degradation mechanisms are being managed effectively.

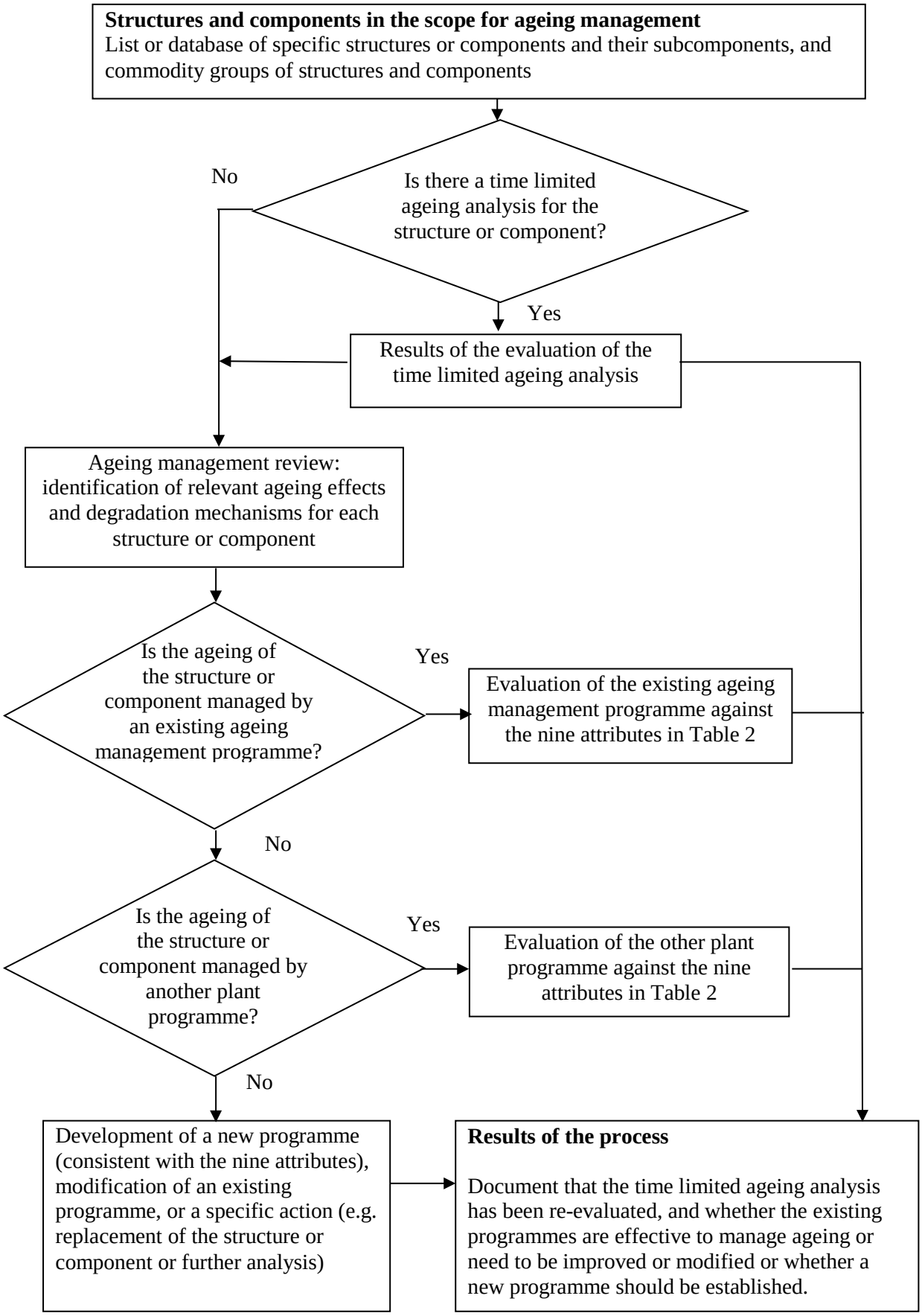

FIG. 4. Process for identifying programmes to manage the ageing of structures or components

Identification of relevant ageing effects and degradation mechanisms of structures or components

5.27 All relevant ageing effects and degradation mechanisms for each in-scope structure or component should be identified based on the understanding of ageing set out in paras 5.28 and 5.29.

5.28 A comprehensive understanding of structures or components and their ageing effects and degradation mechanisms and how these can affect the ability of an SSC to perform its function(s) should be a prerequisite for a systematic ageing management process shown in Fig. 1. This understanding should be based on:

- The design, including the SSC's intended function and applicable regulatory requirements, codes and standards, the design basis and design documents, including safety analyses;
- The fabrication of the SSC, including material properties, manufacturing conditions that may affect ageing and service conditions;
- The operation and maintenance history of the SSC, including commissioning, operational transients and events, power uprating, modifications and replacements;
- Stressors on the structure or component (including loads on the structure or component and the environmental conditions inside and outside the structure or component);
- Results of in-service inspections and surveillance;
- Operating experience, results of research and development, and any post-service examinations;
- Results from walk-downs, inspections and condition assessments, if available;
- Results of the evaluation of time limited ageing analyses.

5.29 The identification process should take into account knowledge of the characteristics of the ageing effect (e.g. necessary conditions under which the effect occurs, rates of degradation), the related degradation mechanisms and their impact on the structure or component's intended function(s).

Identification of the appropriate programme for ageing management

5.30 Appropriate methods to detect, monitor, prevent and mitigate ageing effects and degradation mechanisms for each structure or component should be specified.

5.31 Existing ageing management programmes and other plant programmes should be evaluated for consistency with the nine attributes of Table 2 to determine if they are effective in detecting, monitoring and preventing or mitigating ageing effects and degradation mechanisms in the structures or components for which the programme is credited.

5.32 If existing ageing management programmes and other plant programmes are not sufficiently effective, the existing programme should be improved or modified or a new programme should be developed, consistent with the nine attributes in Table 2.

Reporting on the ageing management review

5.33 Once the approach for managing ageing effects and degradation mechanisms has been determined, documentation should be prepared that logically demonstrates that the ageing effects will be adequately managed.

5.34 All information and conclusions with regard to the scope of ageing management review should be documented, including:

- A description and justification of the methods used to determine the structures or components that are subject to an ageing management review;
- An identification and listing of structures or components subject to an ageing management review and their intended function(s);
- The information sources used to accomplish the above, and any description necessary to clarify their use.

5.35 The methodology and results of the ageing management review should be documented, and should also provide information on the following:

- The current performance and condition of the structure or component, including assessment of any indications of significant ageing effects;
- Identification of the ageing effects and degradation mechanisms requiring management;
- Understanding of ageing, monitoring of ageing and prevention or mitigation of ageing effects;
- Identification of the specific programmes or activities that will manage the ageing effects and degradation mechanisms for each structure, component or commodity grouping subject to an ageing management review, and of the need for development of new programmes;
- A description of how the programmes and activities will manage the ageing effects and degradation mechanisms, considering the current condition of the structure or component;
- Estimation, where feasible, of the future performance, ageing effects and the service life of the structure or component;
- Recommendations for the application of results of the ageing management review in plant operation, maintenance and design.

5.36 If the ageing management review takes account of IGALL [5], then the demonstration should provide a justification that generic references from the nuclear industry are applicable to the plant concerned, based on plant specific features, plant operating and maintenance history, and/or industry developments since the selected references were issued.

AGEING MANAGEMENT PROGRAMMES

5.37 The identified ageing effects and degradation mechanisms that require ageing management should be managed using existing ageing management programmes or existing plant programmes (possibly with improvements or modifications), or new programmes should be developed. These

programmes should be coordinated, implemented and periodically reviewed for improvements as indicated in Fig. 5.

5.38 Each ageing management programme should be consistent with the generic attributes of an effective ageing management programme listed in Table 2.

5.39 Plant programmes or processes used to manage ageing effects and ageing management programmes should include one or more of four types of activity:

- Prevention activities, which preclude the ageing effect from occurring;
- Mitigation activities, which attempt to slow the ageing effects;
- Condition monitoring activities, including inspection and examination for the presence and extent of ageing effects, or surveillance using test samples or coupons intended to mimic the performance of the structure or component;
- Performance monitoring activities, which test the ability of a structure or component to perform its intended functions.

5.40 If necessary, more than one type of activity should be implemented to ensure that ageing effects are adequately managed and that the intended functions of the structure or component are maintained. For example, managing the internal corrosion of piping may rely on a mitigation programme (water chemistry) to minimize susceptibility to corrosion and a condition monitoring programme (ultrasonic inspection) to verify that the corrosion is insignificant.

5.41 If the programme used to manage ageing effects involves inspection by sampling from a specific population of structures or components, the programme should describe and justify the methods used for selecting the samples to be inspected and the sample size, and should demonstrate that the sampling is adequate to provide reasonable assurance that ageing effects on the structure or component will not prevent the performance of its intended functions throughout its lifetime.

5.42 Information and example summaries of ageing management programmes specific to structures or components and specific to degradation mechanisms are provided in Ref. [5, 22].

TABLE 2. GENERIC ATTRIBUTES OF AN EFFECTIVE AGEING MANAGEMENT PROGRAMME

Attribute	Description
1. Scope of the ageing management programme based on understanding ageing	• Structures (including structural elements) and components subject to ageing management • Understanding of ageing phenomena (significant degradation mechanisms, susceptible sites): – Structure or component materials, service conditions, stressors, degradation sites, degradation mechanisms and ageing effects – Structure or component condition indicators and acceptance criteria – Quantitative or qualitative predictive models of relevant ageing phenomena
2. Preventive actions to minimize and control ageing effects	• Specification of preventive actions • Determination of service conditions (i.e. environmental conditions and operating conditions) to be maintained and operating practices aimed at precluding potential degradation of the structure or component
3. Detection of ageing effects	• Specification of parameters to be monitored or inspected • Effective technology (inspection, testing and monitoring methods) for detecting ageing effects before failure of the structure or component
4. Monitoring and trending of ageing effects	• Condition indicators and parameters monitored • Data collected to facilitate assessment of structure or component ageing • Assessment methods (including data analysis and trending)
5. Mitigating ageing effects	• Operations, maintenance, repair and replacement actions to mitigate detected ageing effects and/or degradation of the structure or component
6. Acceptance criteria	• Acceptance criteria against which the need for corrective actions is evaluated
7. Corrective actions	• Corrective actions if a structure or component fails to meet the acceptance criteria
8. Operating experience feedback and feedback of research and development results	• Mechanism that ensures timely feedback of operating experience and research and development results (if applicable), and provides objective evidence that they are taken into account in the ageing management programme
9. Quality management	• Administrative controls that document the implementation of the ageing management programme and actions taken • Indicators to facilitate evaluation and improvement of the ageing management programme • Confirmation (verification) process for ensuring that preventive actions are adequate and appropriate and that all corrective actions have been completed and are effective • Record keeping practices to be followed

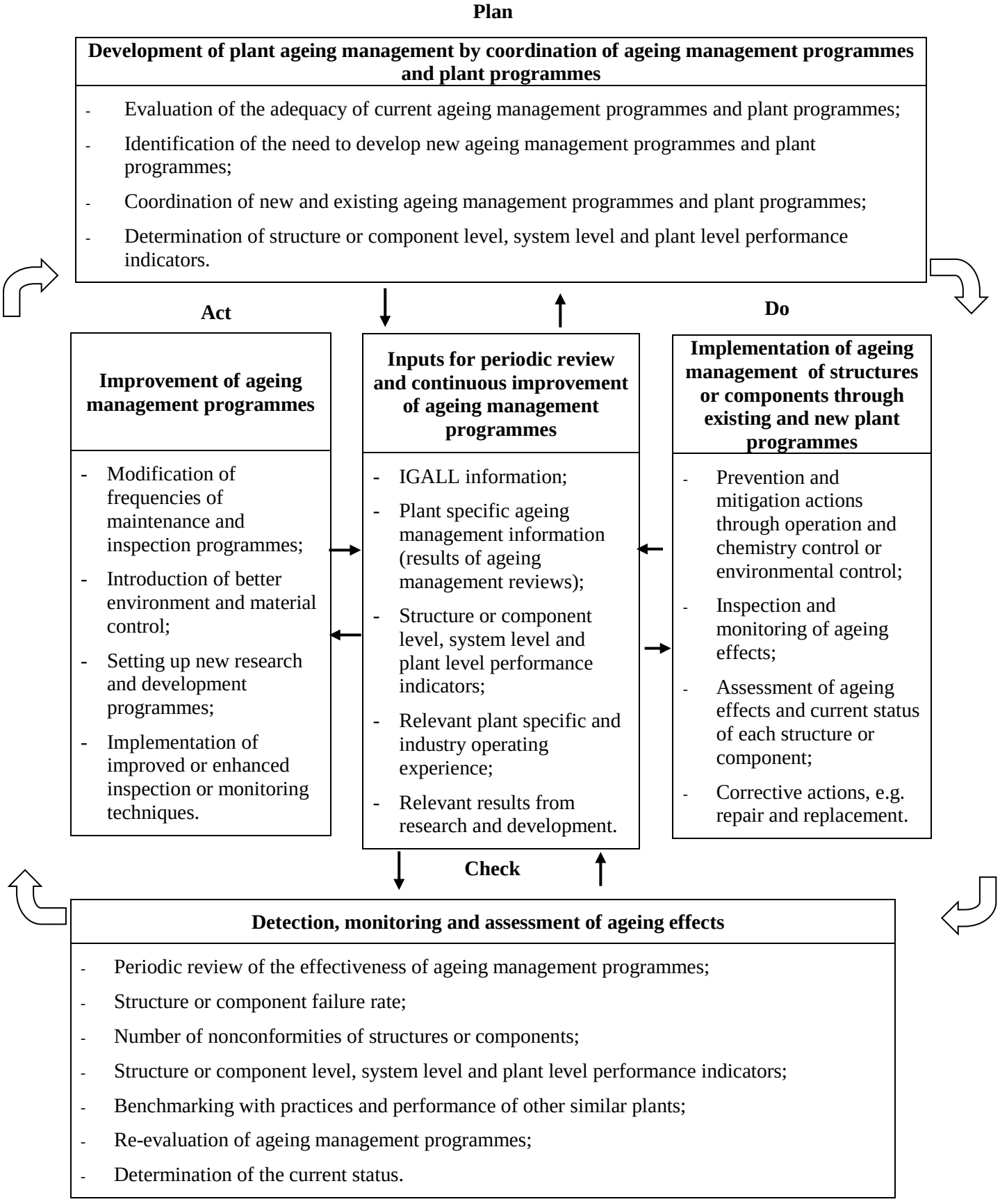

FIG. 5. Development, implementation, review and improvement of ageing management programmes

Development of ageing management programmes

5.43 Ageing management programmes specific to ageing effects and degradation mechanisms or specific to structures and components should be developed. Existing plant programmes should be coordinated and maintained to cover the activities shown in para. 5.39. If necessary, a new programme that includes or supplements these activities should be developed. Such existing or newly developed programmes can be at different levels of detail (e.g. at a structure or component level, commodity group level or system level) depending on their complexity and importance to safety.

5.44 Whether an ageing management programme is structure or component specific or degradation mechanism specific, specific actions relating to the detection, monitoring and prevention or mitigation of ageing effects should be specified within each ageing management programme. Such specific actions may include plant programmes for maintenance, equipment qualification, in-service inspection, testing and surveillance, as well as for controlling operating conditions.

5.45 The development of the ageing management programmes should be based on the results of the ageing management review.

5.46 All programmes developed should comply with relevant national regulatory requirements, codes and standards and the ageing management policy of the plant (see para. 4.3) and should be consistent with the nine attributes of Table 2. If a programme is of such a nature that doesn't meet all of the nine attributes, its use should be properly justified and the justification should be documented.

5.47 Appropriate acceptance criteria for inspection and monitoring of ageing effects should be established for ageing management programmes based on the design basis or the requirements of the structure or component, relevant regulatory requirements and codes and standards, so that a corrective action can be implemented sufficiently before loss of the intended function(s) of the structure or component. The need for sufficient margins should be taken into account in these acceptance criteria.

5.48 Particular attention should be paid in developing ageing management programmes to ensuring that the programme has in place provisions to prevent, detect, evaluate and mitigate ageing effects of anticipated degradation mechanisms, based on the findings from the ageing management review.

5.49 Information on the current status of in-scope structures or components should be collected for subsequent review of the effectiveness of the ageing management programmes. Performance indicators representing the effectiveness of the ageing management programmes should be developed along with the development of the ageing management programmes (see para. 5.56).

5.50 The structure or component specific or the degradation mechanism specific ageing management programmes provided in Ref. [5] should be considered as guidance for the development of ageing management programmes.

Implementation of ageing management programmes

5.51 The ageing management programmes should be implemented in a timely manner to ensure that the intended functions of structures or components continue to be met.

5.52 Detailed implementation procedures that describe preventive and mitigatory actions, monitoring or inspection and assessment actions, acceptance criteria and corrective actions should be established and shared among the different units of the nuclear power plant (e.g. the operations, maintenance and engineering units) that are responsible for implementing ageing management programmes.

5.53 As part of the implementation of the ageing management programmes, appropriate data should be collected and recorded to provide a basis for decisions on the type and timing of ageing management actions.

Review and improvement of ageing management programmes

5.54 The effectiveness of ageing management programmes should be periodically evaluated in the light of current knowledge and feedback from the programme and the performance indicators, and should be updated and adjusted as appropriate. Relevant knowledge includes information on the operation of the structure or component, surveillance and maintenance histories, information from the results of research and development, and operating experience from other nuclear facilities.

5.55 Ageing management programmes should be part of the management system of the operating organization.

5.56 To evaluate effectiveness of the ageing management programmes, performance indicators should be developed and used by the operating organization. Examples of such performance indicators are:

- Material condition with respect to acceptance criteria;
- Trends of data relating to failure and degradation;
- Percentage of recurrent ageing driven failures and instances of degradation;
- Status of compliance with inspection programmes;
- Newly discovered ageing effects and degradation mechanisms;
- Newly developed ageing management programmes.

5.57 Responsible units and other internal or external organizations involved in ageing management should share data and information newly acquired through the implementation of ageing management programmes. Consideration should be given to connecting these data with the existing plant databases, such as the master equipment and component list. Such units and organizations should meet periodically to review these data and information and to discuss whether modification of an ageing management programme or a new ageing management programme is necessary.

5.58 The qualified life of equipment should be reassessed during its lifetime, with account taken of progress in knowledge of degradation mechanisms. If the qualified life of equipment is to be increased, a thorough safety demonstration should be provided by the operating organization.

5.59 The management of the operating organization should provide for performance review and improvement of ageing management programmes. The result of such reviews should be made available to the regulatory body for review and assessment if required by national regulatory requirements.

5.60 Consideration should be given to arranging for peer reviews of ageing management programmes, to obtain an independent assessment in order to establish whether the ageing management programmes are consistent with generally accepted practices [5] and to identify areas for improvement.

5.61 An in-depth review of ageing management should be performed periodically, for example as part of periodic safety review [7] or as part of the safety review for long term operation (see Section 7), in order to assess the effects of ageing on plant safety and to evaluate the effectiveness of plant programmes and practices used to support ageing management throughout plant operation, including long term operation if applicable.

5.62 The in-depth review should demonstrate that ageing effects will continue to be identified and effectively managed for each structure or component throughout the entire period of operation of the plant, including long term operation if applicable. Requirements for modifications of existing plant programmes or development of any new programmes should be specified and applied. The results of this in-depth review should be documented and the findings, including any corrective actions and areas for improvement, should be addressed in a timely manner.

5.63 Adequately funded research and development programmes should be put in place to respond to any new ageing issues and to provide for continuous improvement of the understanding and predictability of degradation mechanisms and the causes of ageing, and associated monitoring and mitigation methods or practices. A strategic approach should be taken to promoting relevant long term research and development programmes.

TIME LIMITED AGEING ANALYSES

5.64 Time limited ageing analyses should meet all six of the following criteria [5]:

1. Time limited ageing analyses should involve SSCs within the scope for ageing management. Scope setting is described in paras 5.14 to 5.21 and illustrated in Fig. 3.
2. Time limited ageing analyses should consider ageing effects. Ageing effects include, but are not limited to: loss of material, changes in dimension, changes in material properties, loss of toughness, loss of pre-stress, settlement, cracking, and loss of dielectric properties.
3. Time limited ageing analyses should involve time limited assumptions defined by the current

operating term. The specified operating term should be explicit in the analysis. Simple assertion that a component is designed for a particular service life or plant lifetime is not sufficient. Any such assertion should be supported by calculations or other analyses that explicitly include a time limit or a time-based assumption.

4. Time limited ageing analysis should have been determined to be relevant by the operating organization in making a safety determination as required by national regulations. Relevancy is a determination that the operating organization makes on the basis of a review of the information available. A calculation or analysis is relevant if it can be shown to have a direct bearing on the action taken as a result of the analysis performed. Analyses are also relevant if they provide the basis for the safety determination for the plant where, in the absence of the analyses, the operating organization might have reached a different safety conclusion or taken a different safety action.
5. Time limited ageing analyses should involve conclusions or provide the basis for conclusions relating to the capability of the SSC to perform its intended function(s).
6. Time limited ageing analyses should be contained or incorporated by reference in the current licensing basis. The current licensing basis includes the technical specifications as well as design basis information, or commitments of the operating organization documented in the plant specific documents contained or incorporated by reference in the current licensing basis including, but not limited to: safety analysis reports, regulatory safety evaluation reports, the fire protection plan or hazard analysis, correspondence with the regulatory body, the documentation of the management system, and topical reports included as references in the safety analysis reports. If a code of record is in the safety analysis report for a particular group of structures or components, reference material should include all calculations called for by that code of record for those structures or components.

5.65 Safety analyses that meet all criteria except for criterion 6 of para. 5.64, and which have been developed in States to demonstrate preparedness for the intended period of operation, should be also considered as time limited ageing analyses. Further examples of time limited ageing analyses for different reactor technologies are provided in Ref. [5].

5.66 Time limited ageing analyses should be evaluated using a projected value of the time dependent parameter, for example through a calculation of the neutron fluence for a certain operating period. This projected value of the time dependent parameter, for example the projected neutron fluence, should then be used to evaluate certain analysis parameters, such as the adjusted nil-ductility temperature or the fracture toughness.

5.67 The validity of time limited ageing analyses over the intended period of operation should be assessed through demonstrating satisfaction against one of the following criteria [5]:

i. The analysis should remain valid for the intended period of operation. The time dependent parameter value for the intended operating period should not exceed the time dependent

parameter value used in the existing analysis.

ii. The analysis should have been projected to the end of the intended period of operation. The value of the analysis parameter value should be changed based on the time dependent parameter projected for the intended operating period, and the value of the analysis parameter should continue to meet the regulatory limit or criterion.

iii. The effects of ageing on the intended function(s) of the structure or component should be adequately managed for the intended period of operation. The value of the analysis parameter should be managed (using an ageing management programme) to ensure that ageing effects are adequately managed and that the value of the analysis parameter will continue to meet the regulatory limit or criterion throughout the intended period of operation.

5.68 If the time limited ageing analyses cannot be found acceptable using criterion (i), (ii), or (iii), then corrective actions should be implemented. Depending on the specific analysis, corrective actions could include:

- Refinement of the analysis to remove excess conservatism;
- Implementation of further actions in operations, maintenance or the ageing management programme;
- Modification, repair or replacement of the structure or component.

5.69 Results of the evaluation of time limited ageing analyses should be used as an input for ageing management review.

DOCUMENTATION OF AGEING MANAGEMENT

5.70 The assumptions, activities, evaluations, assessments and results of the evaluation of the plant programme for ageing management should be documented in accordance with national regulatory requirements as well as in accordance with IAEA safety standards [2, 8]. The documentation should be developed and retained in an auditable and retrievable form.

5.71 The documentation should also include the following to demonstrate that ageing effects will be managed during the planned operating period:

- A description of plant programmes and documentation relevant to ageing management;
- A list of commitments or plans for improvement or development of plant programmes and documentation relevant to ageing management.

5.72 The documentation should include an update of the safety analysis report reflecting the assumptions, activities and results of the plant programme for ageing management.

5.73 The assumptions, activities, evaluations, assessments and results of the plant programme for ageing management should be also reflected in the reports of periodic safety reviews, if applicable.

5.74 If a periodic safety review is to be used to justify long term operation or licence renewal, the safety assessment performed as defined in Ref. [7] should take account of the intended operating period.

6. MANAGEMENT OF TECHNOLOGICAL OBSOLESCENCE

6.1 Technological obsolescence of the SSCs in the plant should be managed through a dedicated plant programme with foresight and anticipation and should be resolved before any associated decrease in reliability and availability occur.

6.2 A technological obsolescence programme should be prepared and implemented to address all SSCs important to safety and spare parts required to maintain those SSCs.

6.3 The technological obsolescence programme should involve participation of the engineering, maintenance, operations and work planning units, plant senior management, and supply chain organizations.

6.4 The technological obsolescence programme should be made available to the regulatory body for review and assessment at a level of detail defined by national regulatory requirements.

6.5 The technological obsolescence programme should be consistent with the nine attributes set out in Table 2, as applicable.

6.6 The technological obsolescence programme should include three basic steps illustrated in Fig. 6:

1. The operating organization should identify the installed SSCs important to safety that are technologically obsolete or will become obsolete in the upcoming years;
2. The identified equipment should be prioritized on the basis of the safety and criticality significance of the obsolete equipment (i.e. its impact on the plant safety);
3. The operating organization should develop and implement effective replacement solutions in a timely manner. Solutions to manage technological obsolescence are illustrated in Fig. 7 and are described in the IGALL technological obsolescence programme [5].

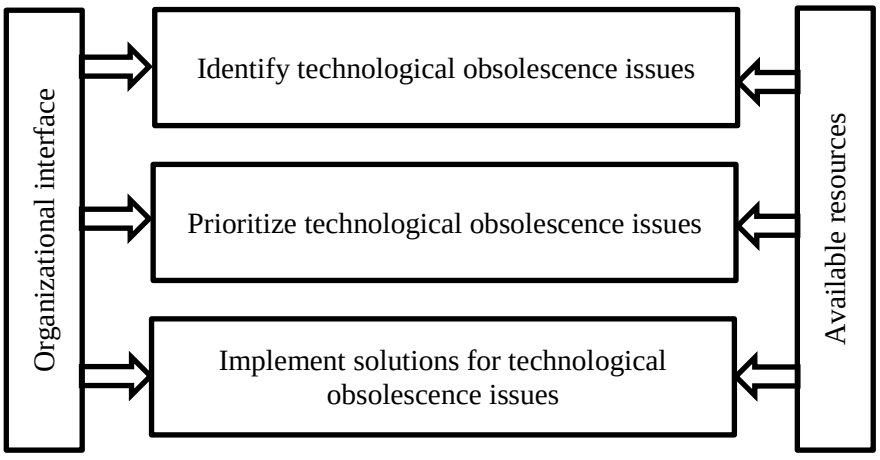

FIG. 6. Basic steps of the generic proactive process to manage obsolescence.

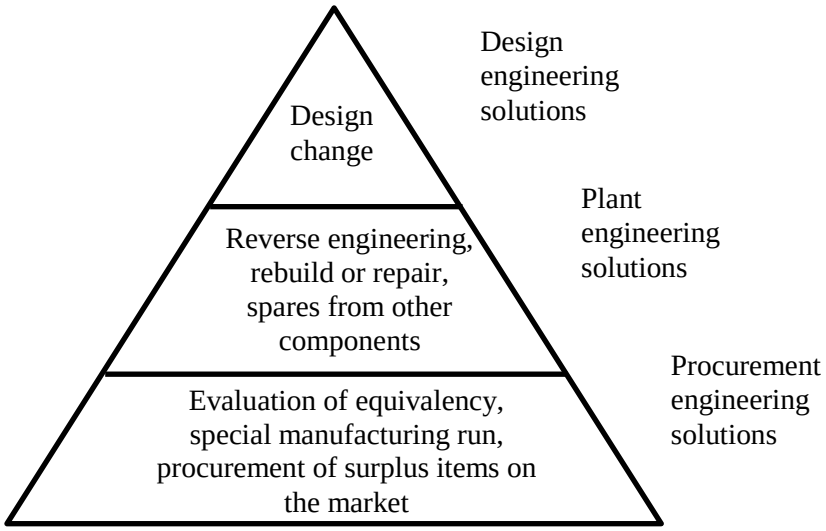

FIG. 7. Solutions to manage technological obsolescence

6.7 For the identification of obsolete equipment and parts, the following activities should be performed:

- Collection of data on structures and components, usually from plant asset management systems (equipment databases with information on manufacturers and parts);
- Determination whether the manufacturer still supports (provides) replacement equipment and spare parts.

6.8 For the prioritization (see step 2 of para 6.6), suitable criteria should be used such as: safety relevance; plant demand; quantity in stock; safety classification of components; failure history; reliability of structures or components; work order information; stock history; uncertainty (spare parts with insufficient data).

6.9 Training should be conducted on obsolescence to educate personnel involved in understanding obsolescence management.

6.10 The operating organization should exchange information and should participate in collaboration within the nuclear industry and should make use of industry tools to identify and resolve common occurrences of technological obsolescence.

6.11 The operating organization should periodically assess the effectiveness of the technological obsolescence programme and should continuously seek to improve performance and efficiency. Self-assessments should be performed concerning the obsolescence programme, its implementation and its effectiveness and any lessons learned should be acted on.

6.12 Detailed information on the technological obsolescence programme is provided in Ref. [5].

7. PROGRAMME FOR LONG TERM OPERATION

7.1 Requirement 16 of SSR-2/2 (Rev. 1) [2] establishes requirements on the programme for long term operation. Further information on the programme for long term operation is provided in Ref. [23].

7.2 Requirements for long term operation should be specified within the national regulatory framework. They should cover, as appropriate, interfaces with the requirements for periodic safety review [7].

ORGANIZATIONAL ARRANGEMENTS

7.3 The operating organization should adopt a comprehensive project structure or similar organizational arrangements for preparation for and implementation of the programme for long term operation, which should take into account the arrangements for the management of physical ageing as described in Section 5. The organizational arrangements for the management of physical ageing, including technological obsolescence, should be properly implemented and should be one of the prerequisites for a decision to pursue long term operation for the nuclear power plant.

7.4 In addition to the existing obligations associated with ageing management, the operating organization should clearly define the additional responsibilities and authorities for preparation for and implementation of long term operation, after considering all the regulatory requirements relevant to long term operation. The operating organization should ensure that appropriate resources are available to accomplish the assigned responsibilities and accountabilities regarding preparation for and implementation of long term operation.

PRINCIPLES OF AND APPROACH TO LONG TERM OPERATION

7.5 Major steps of the programme for long term operation, in particular for ageing management of SSCs necessary to ensure safe long term operation [23], are illustrated in Fig. 8.

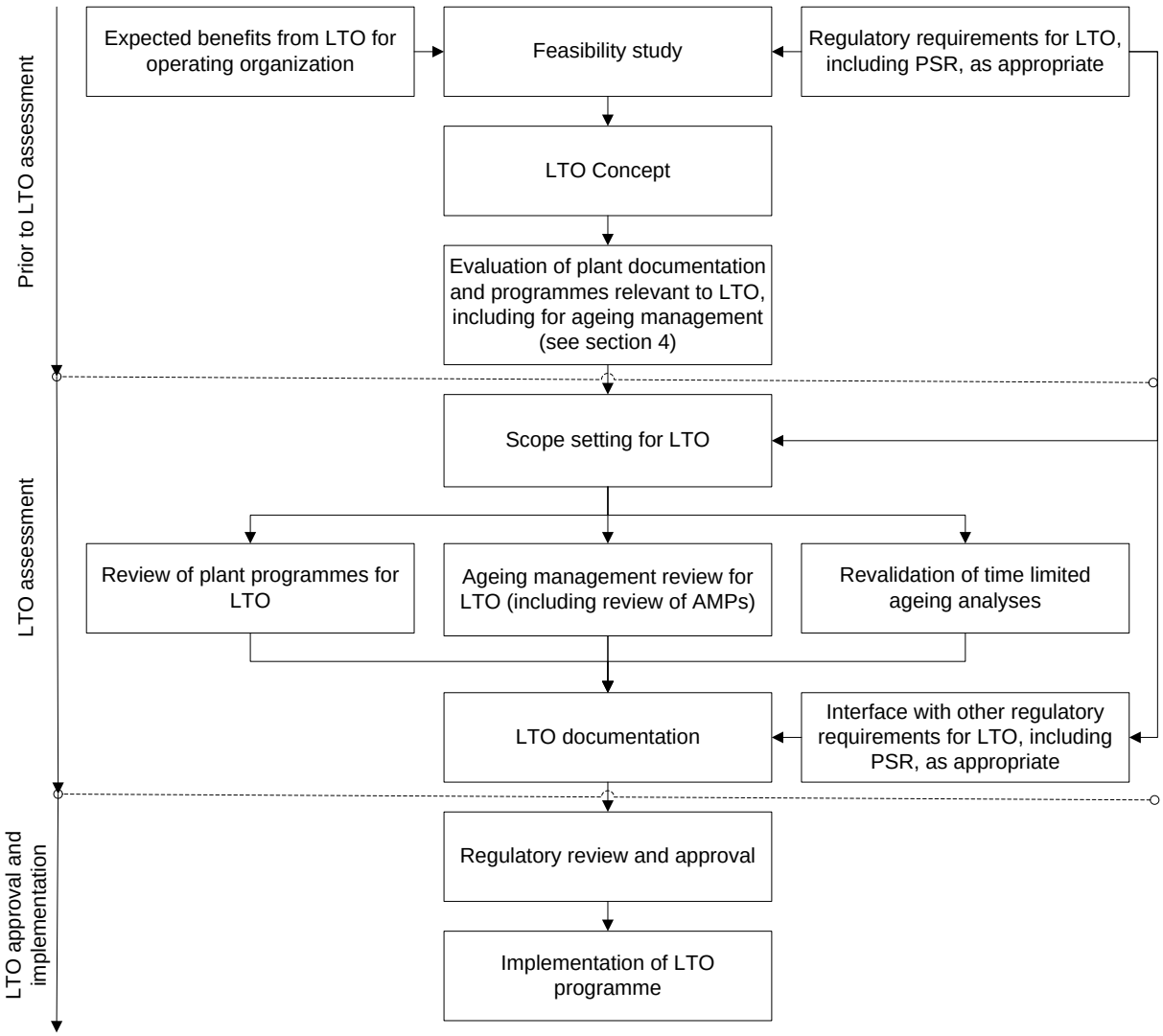

FIG. 8. Overview of major steps of programme for long term operation

7.6 The decision of an operating organization to pursue long term operation is typically based upon an evaluation (a feasibility study) [23] that addresses:

- Strategic elements, such as the need for electrical power and issues concerning diversity in supply;
- Compliance with current codes, standards, and regulations;
- The most recent relevant international standards and guidance;
- A technical assessment of the physical condition of the plant;
- An evaluation of past operating experience at the plant relating to ageing, obsolescence and other safety issues;
- Storage of spent nuclear fuel for long term operation;
- Radioactive waste management for long term operation;
- An assessment of the environmental impact of long term operation as required by national regulations;

– An economic assessment.

7.7 A plant policy for long term operation should be established and should cover the principles of and concept (strategy) for long term operation. When a decision on long term operation is connected to a regulatory process, such as licence renewal or periodic safety review, the plant policy should take account of the related regulatory process.

7.8 The long term operation programme should be based upon the following principles:

a) Operational practices should meet national regulations and should follow international guidelines as applicable, and should be adequate to ensure safe operation of the plant;
b) The regulatory process should be adequate to ensure safe operation of the nuclear power plant is maintained and should focus on ageing effects that need to be properly managed for the planned period of long term operation;
c) The current licensing basis should provide an acceptable level of safety [23] and should be carried over to the planned period of long term operation in the same manner and to the same extent, with the exception of any changes specific to long term operation.

7.9 The concept (strategy) for long term operation should address basic goals and objectives, milestones, activities, organizational roles and responsibilities, interactions with other major projects and interaction with external organizations.

7.10 The operating organization`s staff, in particular plant personnel, should be familiar with long term operation and should understand its principles and concept.

7.11 Ageing management review and evaluation of time limited ageing analyses should have been completed previously in accordance with the recommendations in Section 5; if not, such review and evaluation should be completed for long term operation.

7.12 Technological obsolescence should have been addressed previously in accordance with the recommendations of Section 6; if not, then it should be addressed for long term operation.

7.13 The assessment for long term operation should demonstrate, in particular, that ageing effects will be adequately managed so that the intended functions of SSCs can be maintained consistent with the plant’s current licensing basis for the planned period of long term operation.

7.14 The approach to an assessment for long term operation is outlined in Fig. 8. With regard to ageing, an overview of major steps of the programme for long term operation should involve the following main steps:

a) Demonstration that ageing effects will continue to be identified and managed for each structure or component in the scope of long term operation for the planned period of long term operation (including the feedback of operating experience and research and development findings);

b) Review of time limited ageing analyses to ensure that the analyses continue to meet the criteria specified in para. 5.67.

7.15 The approach to an assessment for long term operation should also take into account the licensing processes and other licensing related requirements, such as the performance of a periodic safety review [7]. This is to ensure that any safety improvements required for long term operation will be addressed as part of the preparation for long term operation.

DEVELOPMENT OF PROGRAMME FOR LONG TERM OPERATION

7.16 Ageing management for the period of long term operation should use the approach described in Section 5, accounting for the differences that will occur for period of the long term operation, for example longer operating times and higher neutron fluence levels. In addition, changes that will occur before the period of long term operation should be considered, including changes in regulatory requirements, codes and standards, knowledge and operating experience.

7.17 Time limited ageing analyses should be re-evaluated for the planned period of long term operation and it should be demonstrated that they meet the criteria of para. 5.67.

7.18 The programme for long term operation should include the following activities, evaluations, assessments and results:

a) The method of scope setting, the results obtained (structures or components in scope and out of scope of long term operation), and supporting technical justifications as outlined in Section 5.
b) Demonstration that the programmes credited for long term operation support the conclusion that the intended functions of SSCs and the required safety margins will be maintained. This demonstration should address the following topics:
   (i) A description of the intended functions of the structures or components;
   (ii) Identification of applicable ageing effects and degradation mechanisms based on, for example, the materials used, the environment and operating experience;
   (iii) Specification and description of operational programmes and ageing management programmes that manage the identified ageing effects;
   (iv) Demonstration that these operational programmes and ageing management programmes (including new programmes) are effective.
c) Demonstration that the review performed for the SSCs within the scope of long term operation is consistent with the process outlined in Section 5. A technical justification should be provided that:
   (i) Demonstrates that ageing effects will be adequately managed for each structure or component in such a way that the intended function(s) of the structure or component will

be maintained throughout the planned period of long term operation in a manner that is consistent with the current licensing basis;

(ii) Ensures that operating experience and research findings are adequately reflected in assessing ageing effects of structures or components that are in scope for long term operation and will continue to be taken into account during the entire period of long term operation.

d) Demonstration that the time limited ageing analyses have been revalidated and that the evaluation includes:

(i) Identification of time limited ageing analyses in accordance with the definition specified in para. 5.64;

(ii) Revalidation of each identified time limited ageing analysis in accordance with the recommendations provided in para 7.26 to demonstrate that the intended function(s) of the structure or component will be maintained throughout the planned period of long term operation in a manner that is consistent with the current licensing basis.

e) The implementation of the programme for long term operation specifying the corrective actions for safe long term operation, and the schedule and commitments of the operating organization in this respect.

7.19 The programme for long term operation should address the safety improvements required for safe long term operation, the schedule and the commitments of the operating organization in this respect.

SCOPE SETTING OF SSCs FOR LONG TERM OPERATION

7.20 Scope setting for long term operation should follow the approach set out in Section 5, accounting for differences in regulatory requirements, and codes and standards.

7.21 The process set out in Section 5 should be used to identify programmes to manage the ageing of in-scope structures or components.

AGEING MANAGEMENT REVIEW FOR LONG TERM OPERATION

7.22 The ageing management review for long term operation should follow the approach set out in Section 5, accounting for differences in regulatory requirements, codes and standards, knowledge and operating experience for the period of long term operation.

7.23 The ageing management review for long term operation should focus on the following issues:

- Whether any new ageing effect or degradation mechanism is anticipated in the course of the planned period of long term operation;
- Whether the significance, degradation rate or susceptible sites of degradation mechanisms are expected to change during the planned period of long term operation;

– Whether current relevant operating experience and research findings have been incorporated into ageing management programmes.

7.24 If the operating organization has not performed any ageing management review, the results of an ageing management review for long term operation should be used to identify or develop effective ageing management programmes in order to detect and mitigate those ageing effects identified in the ageing management review before the integrity and functional capability of the SSCs are compromised.

7.25 The ageing management review should provide a clear demonstration that ageing effects will continue to be identified and managed for each structure or component in the scope of long term operation for the planned period of long term operation.

REVIEW OF PLANT PROGRAMMES AND AGEING MANAGEMENT PROGRAMMES FOR LONG TERM OPERATION

7.26 On the basis of the results of the ageing management review for long term operation, the existing plant programmes used for ageing management and existing ageing management programmes should be reviewed to ensure that they will remain effective to manage the effects identified for the planned period of long term operation. This review should identify programme modifications and/or new programmes necessary to ensure that the structures or components will be able to perform their intended function(s) for the planned period of long term operation.

7.27 Any existing and new plant programmes for long term operation should be reviewed to determine whether they are consistent with the nine attributes set out in Table 2. In addition, the plant documentation and programmes described in Section 4 should also be reviewed with respect to the planned period of long term operation.

REVALIDATION OF TIME LIMITED AGEING ANALYSES

7.28 Time limited ageing analyses should be reviewed to determine the continued acceptability of the analysed structure or component for the planned period of long term operation period, in accordance with para. 5.67. In this case, the time dependent parameter should be determined from a re-evaluation or analysis of the operating history of the plant that is projected to the end of the planned period of long term operation, to define a value of the parameter that applies to or bounds the expected value of the parameter at the end of the planned period of long term operation. The value of the time dependent parameter applicable to the period of long term operation should be used to re-evaluate the time limited ageing analyses as described in para. 5.67.

DOCUMENTATION IN SUPPORT OF LONG TERM OPERATION

7.29 The assumptions, activities, evaluations, assessments and results of the plant programme for

long term operation should be documented by the operating organization in accordance with national regulatory requirements as well as in accordance with the IAEA safety standards [2]. The documentation should be developed and retained in an auditable and retrievable form so that it provides a part of the technical basis for approval of long term operation.

7.30 The documentation should provide detailed information on each element outlined in para. 7.18 and 7.19, and other information required by national regulatory requirements.

7.31 With regard to ageing management, the documentation should also include the following to demonstrate that ageing effects will be managed throughout the planned period of long term operation:

- A description of plant programmes and documentation relevant to ageing management throughout the planned period of long term operation;
- A list of commitments for improvement or for the development of plant programmes and documentation relevant to ageing management throughout the period long term operation, and information on the implementation of new ageing management programmes.

7.32 The methodology used to carry out the ageing management review for long term operation should be documented and justified.

7.33 All information and conclusions with regard to the scope of an ageing management review for long term operation should be documented, including:

- An identification and listing of SSCs subject to an ageing management review and their intended functions;
- A description and justification of the methods used to determine the structures or components that are subject to an ageing management review;
- The information sources used to accomplish the above, and any description necessary to clarify their use.

7.34 The results of the ageing management review for long term operation should be documented in an appropriate report. The report should address the understanding of ageing, the monitoring of ageing and the prevention and mitigation of ageing effects. In addition, recommendations should be provided for the application of results of the ageing management review in plant operation, maintenance and design.

7.35 Documentation of the demonstration that ageing effects will be adequately managed during long term operation should include the following:

- Identification of the ageing effects and degradation mechanisms requiring management;
- Identification of the specific programmes or activities that will manage the ageing effects and degradation mechanisms for each structure, component or commodity grouping listed;
- A description of how the programmes and activities will manage the ageing effects and

degradation mechanisms.

7.36 The documentation should include an update of the safety analysis report and other documents required by the licensing process reflecting the assumptions, activities and results of the plant's programme for long term operation. The update to the safety analysis report should also include documentation of the revalidation of the time limited ageing analyses for the period of long term operation.

7.37 The assumptions, activities, evaluations, assessments, and results of the plant programme for long term operation should be also reflected in the periodic safety review report, if applicable.

7.38 If the periodic safety review is used as a licensing tool, the safety assessment performed for safety factors 2, 3, 4, and 5 as defined in SSG-25 [7] should consider the entire planned period of long term operation.

REGULATORY REVIEW AND APPROVAL

7.39 To ensure the safe long term operation of a nuclear power plant, the operating organization should demonstrate, and the regulatory body should oversee, that the safety of the nuclear power plant will be maintained throughout the period of long term operation in accordance with current safety standards and national regulatory requirements.

7.40 The demonstration of safety for long term operation should be provided to the regulatory body for review and approval at a level of detail and in a manner defined by national regulatory requirements. The justification should include trends of expected ageing effects during the period of long term operation based on past studies, such as studies undertaken in past periodic safety reviews, and, when appropriate, the plant modifications to be implemented to improve safety.

IMPLEMENTATION OF THE PROGRAMME FOR LONG TERM OPERATION

7.41 The programme for long term operation should be implemented by the operating organization in a manner consistent with the requirements of the national regulatory body and national regulations.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Design, IAEA Safety Standards Series No. SSR-2/1 (Rev.1), IAEA, Vienna (2016).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Power Plants: Commissioning and Operation, IAEA Safety Standards Series No. SSR-2/2 (Rev.1), IAEA, Vienna (2016).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4 (Rev.1), IAEA, Vienna (2016).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GSR Part 1 (Rev.1), IAEA, Vienna (2016).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL), Safety Reports Series No. 82, IAEA, Vienna (2015).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY Approaches to Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL) Final Report, IAEA-TECDOC-1736, IAEA, Vienna (2014).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-25, IAEA, Vienna (2013).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership and Management for Safety, IAEA Safety Standards Series No. GSR Part 2, IAEA, Vienna (2016).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Storage of Spent Nuclear Fuel, IAEA Safety Standards Series No. SSG-15, IAEA, Vienna (2012).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Maintenance, Surveillance and In-service Inspection in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.6, IAEA, Vienna (2002).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Proactive Management of Ageing for Nuclear Power Plants, Safety Reports Series No. 62, IAEA, Vienna (2009).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Format and Content of the Safety Analysis Report for Nuclear Power Plants, IAEA Safety Standards Series No. GS-G-4.1, IAEA, Vienna (2004).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Modifications to Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.3, IAEA, Vienna (2001).

[14] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Maintaining the Design Integrity of Nuclear Installations throughout their Operating Life, INSAG-19, IAEA, Vienna (2003).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Equipment Qualification in Operational Nuclear Power Plants: Upgrading, Preserving and Reviewing, Safety Reports Series No. 3, IAEA, Vienna (1998).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Instrumentation and Control Systems Important to Safety in Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-1.3, IAEA, Vienna (2002).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Chemistry Programme for Water Cooled Nuclear Power Plants, IAEA Safety Standards Series No. SSG-13, IAEA, Vienna (2011).

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

[19] INTERNATIONAL ATOMIC ENERGY AGENCY, Management System for Nuclear Installations, IAEA Safety Standards Series No. GS-G-3.5, IAEA, Vienna (2009).

[20] INTERNATIONAL ATOMIC ENERGY AGENCY, Operating Organization for Nuclear Power Plants, IAEA Safety Standards Series No. NS-G-2.4, IAEA, Vienna (2001).

[21] INTERNATIONAL ATOMIC ENERGY AGENCY, Data Collection and Record Keeping for the Management of Nuclear Power Plant Ageing, Safety Series No. 50-P-3, IAEA, Vienna (1991).

[22] INTERNATIONAL ATOMIC ENERGY AGENCY, Ageing Management of Concrete

Structures in Nuclear Power Plants, IAEA Nuclear Energy Series No. NP-T-3.5, IAEA, Vienna (2016).
[23] INTERNATIONAL ATOMIC ENERGY AGENCY, Safe Long Term Operation of Nuclear Power Plants, Safety Reports Series No. 57, IAEA, Vienna (2008).

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